THE ENERGY TRANSITION

OUTLOOK AND IMPLICATIONS FOR UPSTREAM COMMODITIES

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SAILINGSTONE
CAPITAL PARTNERS LLC

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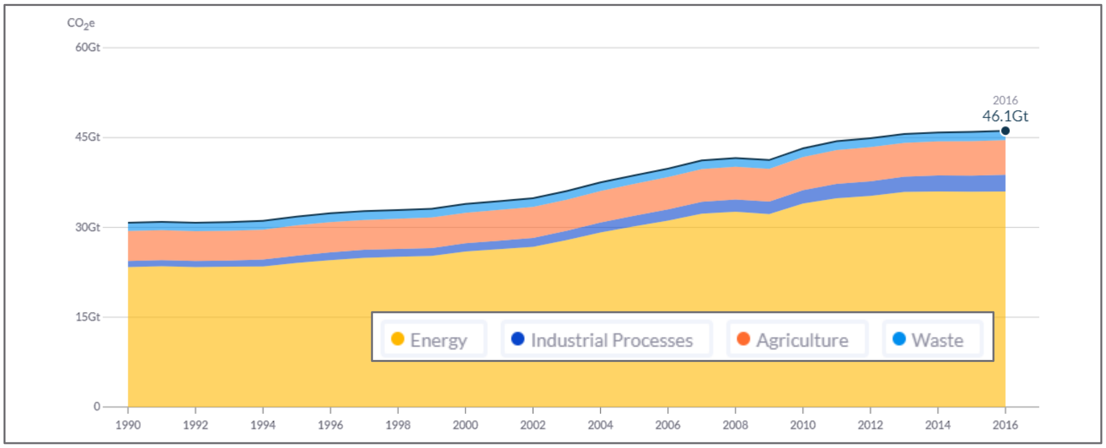
EXECUTIVE SUMMARY

Tackling climate change is one of the world's top priorities. In 2019, a survey of more than 30,000 people from 28 countries revealed that more than half believed climate change was "very" or "quite" likely to bring about the extinction of the human race[1]. At the same time, it is widely acknowledged that energy access is essential for economic progress and advancements in living standards, particularly in emerging regions. As a result, there is growing momentum across government, industry, academia, and the investment community to identify and implement solutions that will reduce greenhouse gas ("GHG") emissions without sacrificing economic and humanitarian imperatives. Since energy consumption generates more than 70% of total annual anthropogenic GHG emissions and is responsible for the vast majority of growth over the last 25 years, the prospect of a greener future is tied to the development of a clean, expansive, cost-effective energy network.

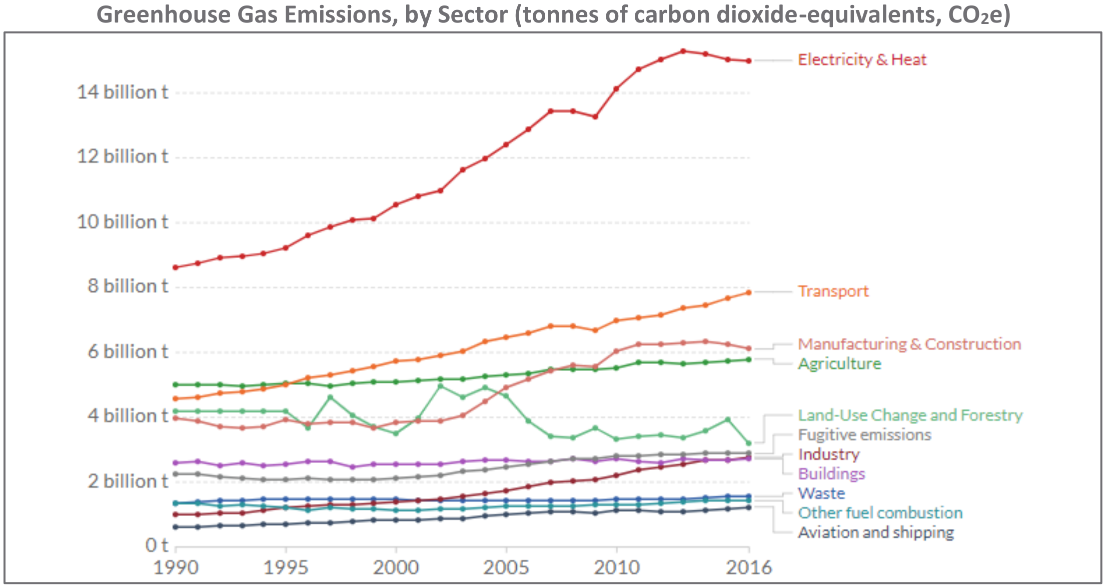
Historical Global Emissions



Source: World Resources Institute, https://www.wri.org/blog/2020/02/greenhouse-gas-emissions-by-country-sector#:~:text=Energy%20consumption%20is%20by%20far,emissions%20and%20other%20fuel%20combustion.

This evolution, commonly referred to as the energy transition, revolves around electricity and transportation as they are the primary GHG culprits.

Greenhouse Gas Emissions, by Sector (tonnes of carbon dioxide-equivalents, CO_2e)



Source: CAIT Climate Date Explorer via Climate Watch. *C02 and Greenhouse Gas Emissions*, Ritchie and Roser, https://ourworldindata.org/co2-and-other-greenhouse-gas-emissions#

[1] YouGov International Survey, September 15, 2019. https://yougov.co.uk/topics/science/articles-reports/2019/09/15/international-poll-most-expect-feel-impact-climate

Critically, a large, stable installed electrical generation/transmission/distribution network already exists, and renewable power technologies are becoming increasingly viable. At the same time, the transportation sector is being revolutionized by the rapid improvement in and availability of affordable electric vehicles. So, the idea is to "green the grid," and then electrify as many different sources of energy demand as possible.

Today, this is more than just a theoretical modelling exercise as technological advancements and scale are driving down costs and improving the efficiencies of renewable energy sources, electric vehicles, and storage solutions. In addition, there is growing consensus around the world that these initiatives can support economic activity and employment while also working to address pressing socio-economic concerns related to energy access.

One area which has not received as much attention is the implication of the energy transition for upstream commodity demand

However, the path forward is not without its potential pitfalls. The influence and inertia of incumbents, questions around funding sources, the lack of pricing externalities for carbon emissions and key but immature technologies have all been identified as possible stumbling blocks. One area which has not received as much attention is the implication of the energy transition for upstream commodity demand and the ability of different commodity complexes to meet that demand.

In fact, to the extent that there has been any focus on what the energy transition means for upstream commodities, typically it has been in the context of divestment, stranded asset risks, etc. And for some commodities such as thermal coal today, and perhaps oil longer term, the outlook is fairly dire. However, certain raw materials absolutely will be required to implement the technologies and infrastructure necessary to reduce carbon and other emissions and improve access to energy on a global basis. This creates an intriguing 10- to 20-year secular backdrop which has yet to be appreciated by most investors. More immediately, the fundamentals for parts of this upstream complex are improving cyclically while valuations remain depressed. In other words, we find ourselves in one of those rare moments in time when we can invest in what looks to be a compelling secular opportunity just as the cycle is moving in our favor.

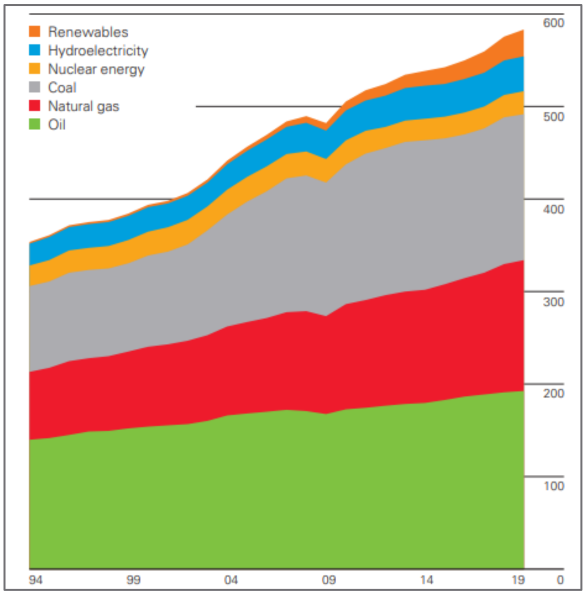
The fundamentals for parts of this upstream complex are improving cyclically while valuations remain depressed

In this paper, we will attempt to put some context around historical and future energy supply and demand and review the key enablers for the energy transition. Then, we will investigate what the emergence of green energy means for two commodities which we believe will be central pillars in the creation of an energy complex that will support the world's ability to "electrify everything" – natural gas and copper.

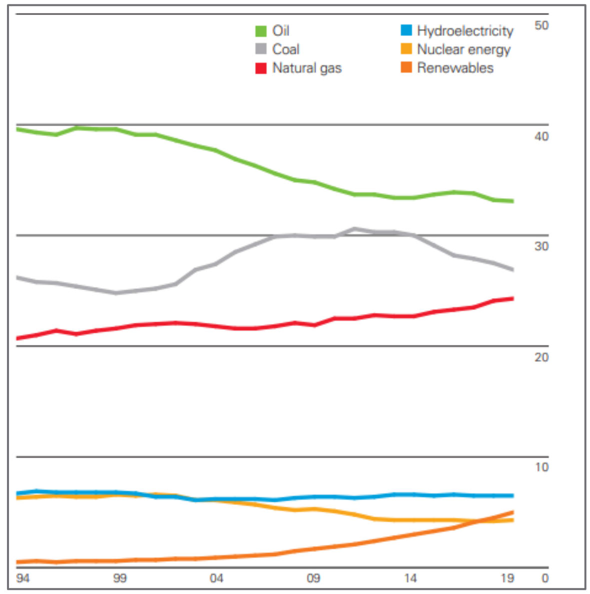
ENERGY IN CONTEXT

The world consumes almost 600 exajoules ("EJ") of primary energy per year, the vast majority of which is derived from hydrocarbons[2].

World Consumption (Exajoules)



Shares of Global Primary Energy (Percentage)

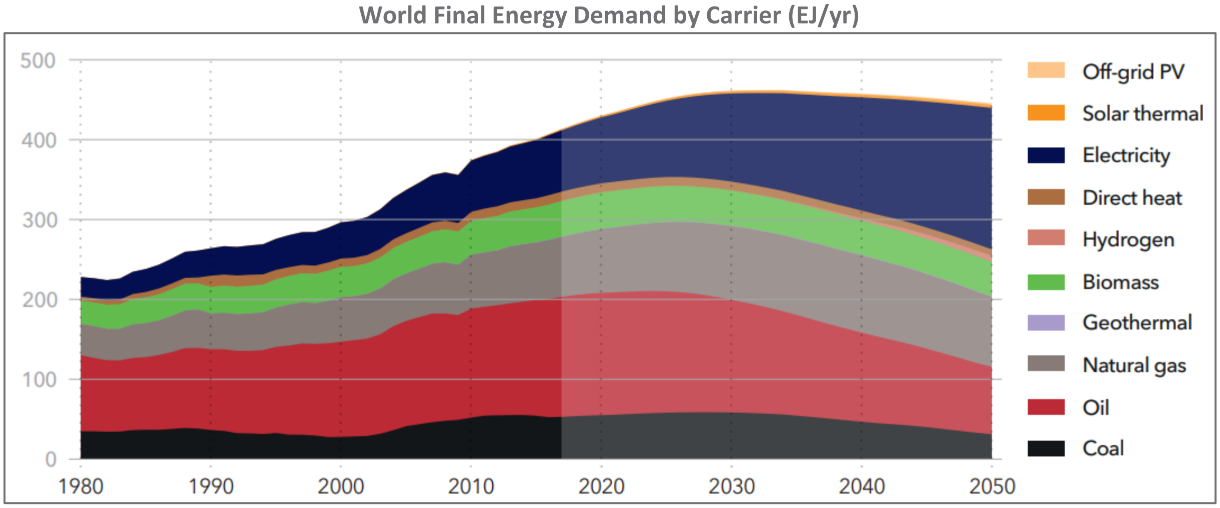


Source: BP Statistical Review of World Energy 2020, https://www.bp.com/content/dam/bp/business-sites/en/global/corporate/pdfs/energy-economics/statistical-review/bp-stats-review-2020-full-report.pdf

Natural gas consumption has been increasing for the last 25 years, while renewables began to inflect about 15 years ago. Both have taken share from coal and oil but still comprise less than a third of global primary energy.

The same trends are evident when looking at world final energy demand. The difference in scale and composition between primary and final energy demand reflects the impact of conversion losses and the fact that a significant amount of primary energy is dedicated to generating electricity.

World Final Energy Demand by Carrier (EJ/yr)



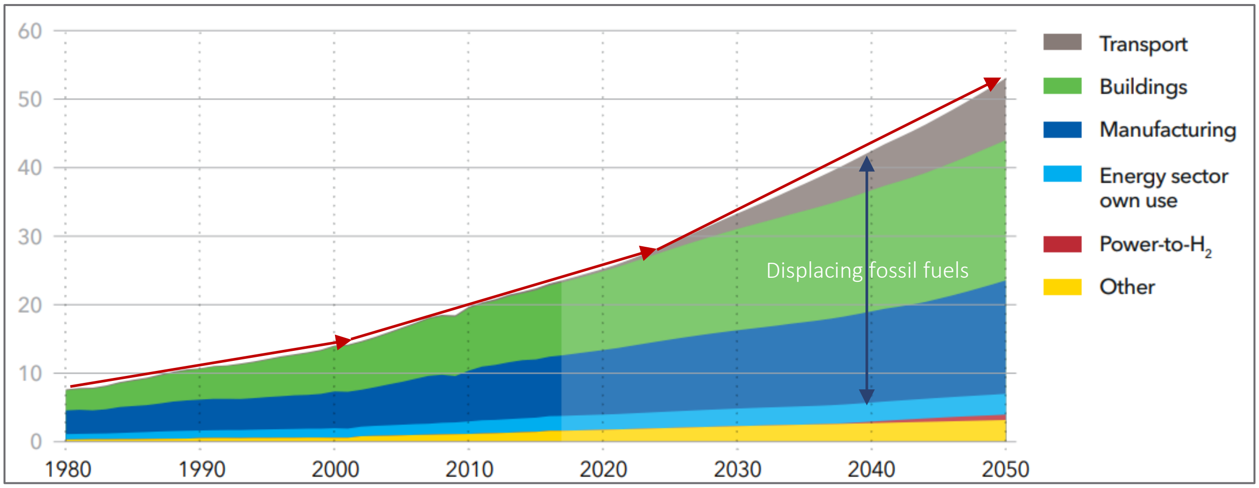
Source: DNV-GL *Energy Transition and Outlook 2019*

[2] For context, a study of Tour de France riders estimated that the average rider expended 25.4 megajoules over the course of the race. If that is the energy required to complete the Tour, and every person in the world did it five times, that would equate to 1 exajoule. To match world energy consumption, we would each have to average about 10 Tours per day, every day of the year.

Natural gas and electricity demand have improved while non-electricity coal and oil have largely flatlined for the last decade or so. The forecast is for overall energy consumption to continue to increase as a function of an expanding global economy and population until efficiency gains slow growth around 2030. More importantly, over time electricity and to a lesser extent natural gas begin to meaningfully displace oil and coal as final energy carriers.

The drivers of electrification become more evident when the sub-components of end-market demand are examined. This is just a more detailed analysis of the dark blue wedge above.

World Electricity Demand by Sector (PWh/yr)

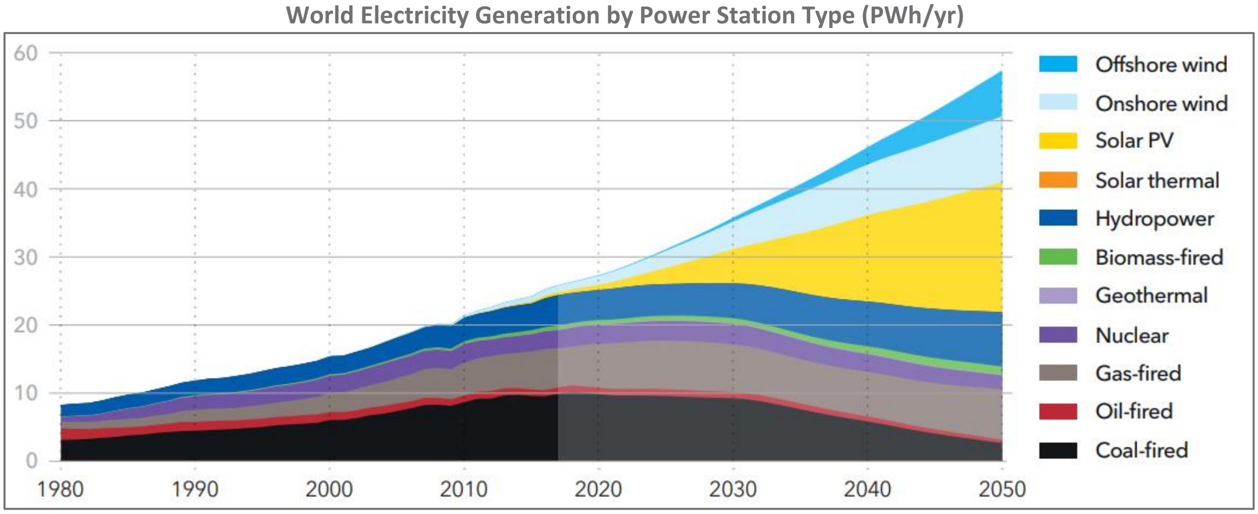


Source: DNV-GL *Energy Transition and Outlook 2019*

After inflecting in 2000 with the urbanization of China and other emerging economies, electricity demand is expected to accelerate in the coming years as the manufacturing, buildings and transport sectors rely more heavily on electricity as opposed to fossil fuels as an energy source.

Backfilling this increased electricity demand with lower/zero carbon alternatives is the key to the success of the energy transition.

World Electricity Generation by Power Station Type (PWh/yr)



Source: DNV-GL *Energy Transition and Outlook 2019*

In this forecast, renewables grow from single digit percentages to almost two-thirds of electricity supply, natural gas grows slightly, and coal is effectively removed. This would result in a significant reduction in GHG emissions while more than doubling global electricity production, fulfilling the objectives of the energy transition.

ENABLERS OF THE ENERGY TRANSITION

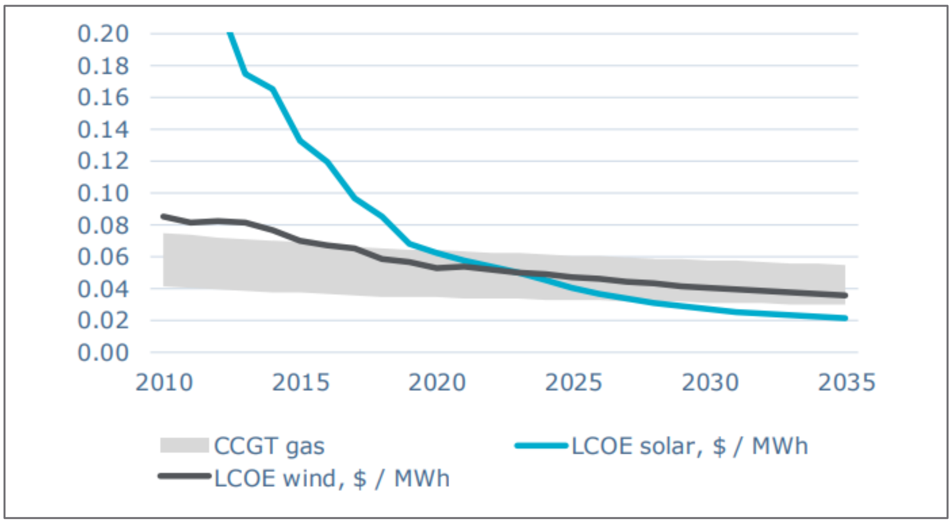
> *Prediction is very difficult, especially if it's about the future*
>
> Nils Bohr, Nobel laureate in Physics

We acknowledge that the forecasts discussed above are both far more accurate than what we could produce, and precisely wrong. However, it is important to think about the feasibility of the scenarios as the general trends are far more relevant than specific end points. What, then are the key enablers of the energy transition?

Increasingly Competitive Zero Carbon Alternatives

The rapid reduction in unit costs and continued improvement in relative economics have been critical to accelerating the installation of renewable energy sources. Levelized cost of energy, or "LCOE" is a standardized measure of the cost to install a unit of electricity generation across different technologies.

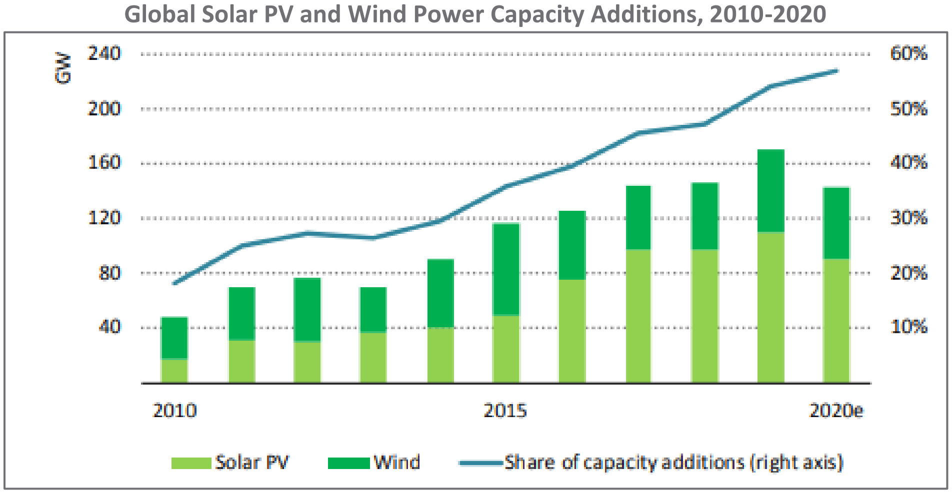
LCOE Forecast



Source: Canaccord Genuity Research, BTIG Research, *Energy – Gas to Power*, Q2 2020

Unit costs for renewables, particularly solar, have fallen meaningfully and are expected to continue to decline, allowing investment decisions to be less reliant on government subsidies. In fact, the IEA estimates that wind and solar PV comprised more than 50% of total power capacity additions in 2019, up from less than 20% in 2010.

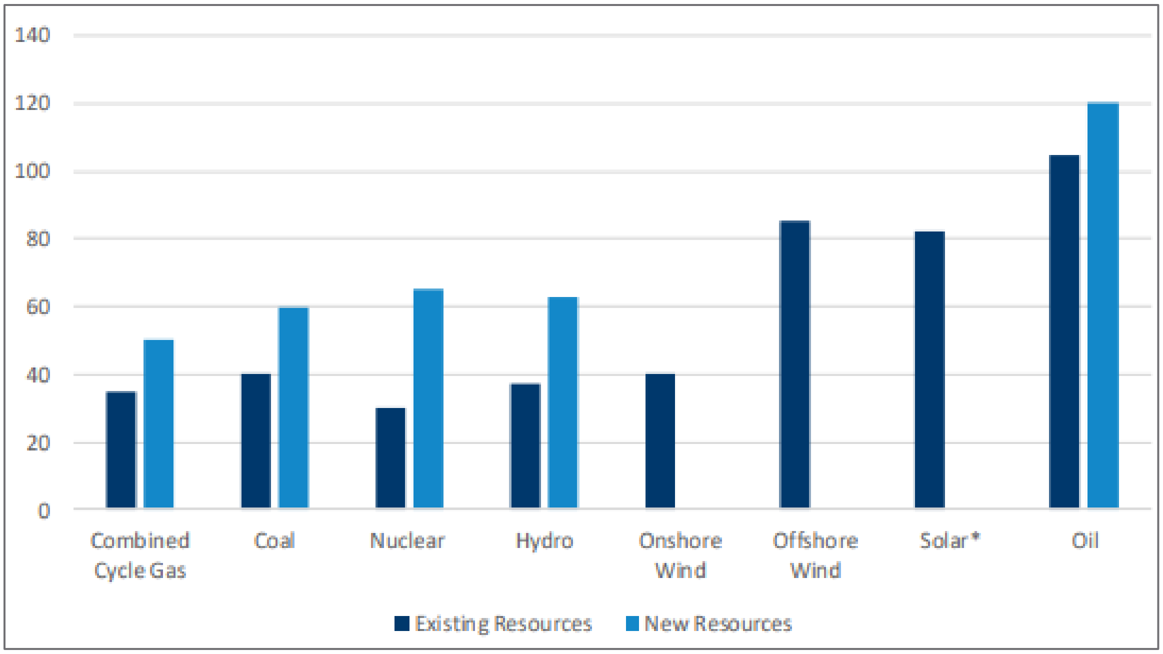
Global Solar PV and Wind Power Capacity Additions, 2010-2020



Source: IEA, World Energy Outlook Special Report, June 10, 2020 p 48

However, it is important to note that LCOE is, at best, a crude metric which fails to capture numerous site-specific expenses and constraints. Furthermore, new build economics generally remain more expensive than conventional installed capacity.

Current LCOE



Source: Canaccord Genuity Research, BTIG Research, *Energy – Gas to Power*, Q2 2020

While we expect renewable costs to continue to fall and installations to grow exponentially, the transition to a completely green electricity base will require a mix of both lower carbon conventional supply and zero carbon new builds over the course of the next few decades. In addition, it will require policy support from governments around the world.

The transition to a completely green electricity base will require a mix of both lower carbon conventional supply and zero carbon new builds over the next few decades

Economic Benefits

Fortunately, there appears to be a growing awareness that "green investment" can be a key contributor to economic growth and employment, particularly in a post-pandemic world. The EU's "Green Deal" is a €7 trillion proposal which Goldman Sachs and Iberdola calculate could create €0.8 of incremental GDP for every €1 spent[3]. The IEA estimates that by spending $1 trillion in each of the next three years on sustainable energy, global GDP would increase by 1.1% and 9 million jobs would either be saved or created each year[4].

There appears to be a growing awareness that "green investment" can be a key contributor to economic growth and employment, particularly in a post-pandemic world

Businesses are reacting as well. On June 17, 2020, Xcel Energy filed a plan with the Minnesota Public Utilities Commission to invest $3 billion in accelerated and incremental renewable and efficiency projects in response to the agency's request for proposals from energy companies to help the state recover from COVID-19. The plan would add approximately 5,000 jobs and allow the utility to meet its pledge to keep consumer rates "low and stable."

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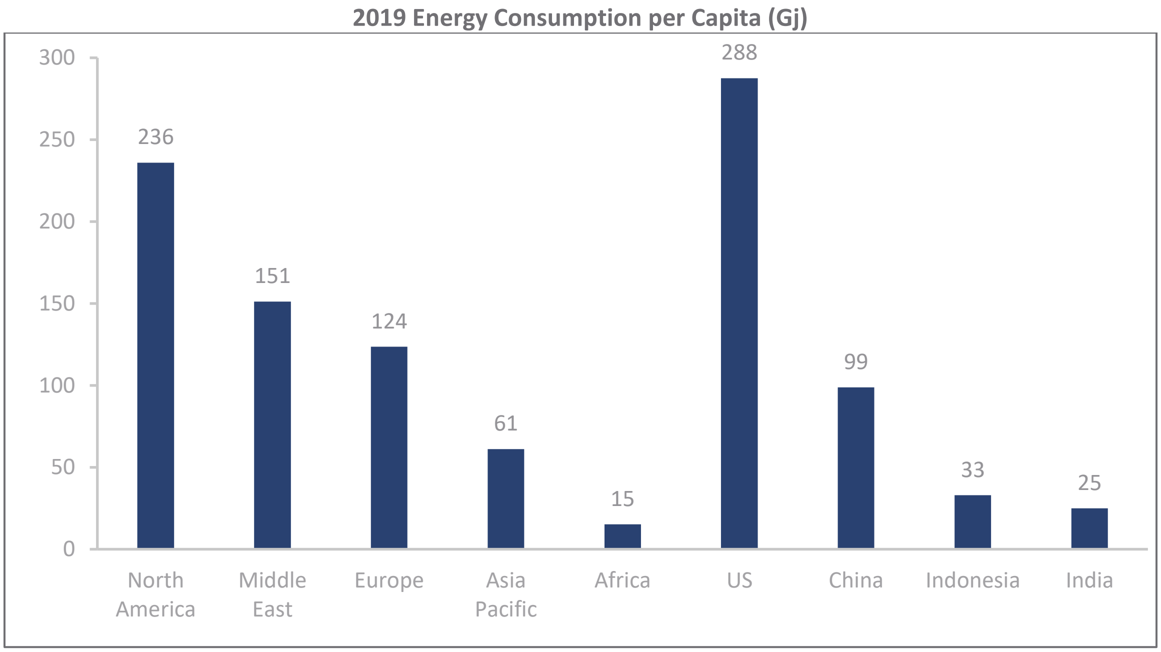
[3] Iberdola, Goldman Sachs Research, *The EU Green Deal,* Q2 2020
[4] IEA, *World Energy Outlook Special Report,* June 2020, p 14

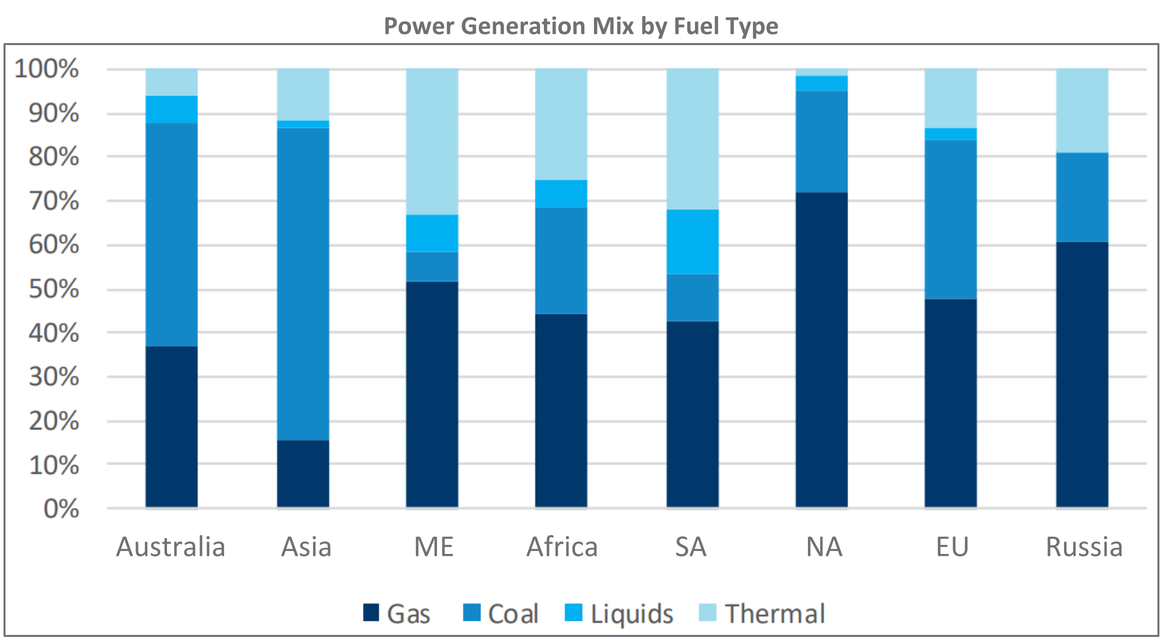
Energy Access

In addition to economic benefits, there are the humanitarian aspects of expanding access to clean, reliable energy, particularly in emerging economies. The dispersion of energy access across the global population is startling.



Source: BP Statistical Review of World Energy 2020

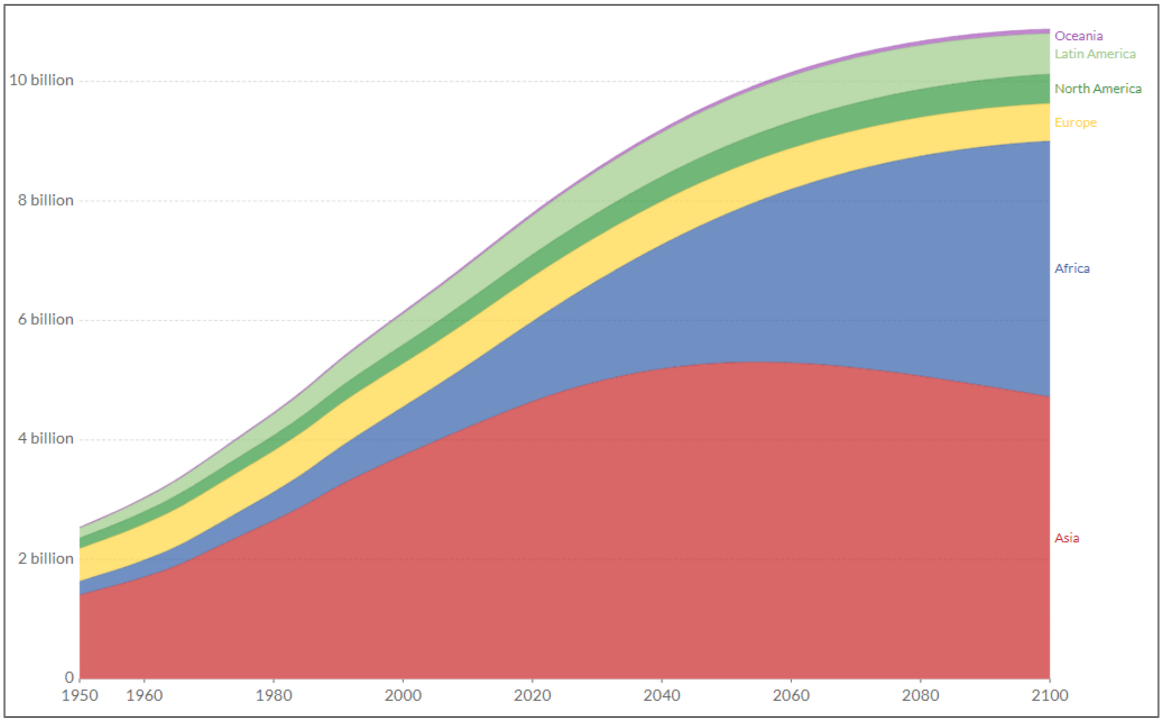
In addition, many of the regions with more limited access to energy rely on coal, liquid, and thermal fuels (i.e. wood, grass, dung) for power generation.



Source: BTIG Research, Energy – Gas to Power, Q2 2020

These areas are also likely to see the most significant population growth going forward.

World Population by Region Projected to 2100
Based on UN's medium population scenario

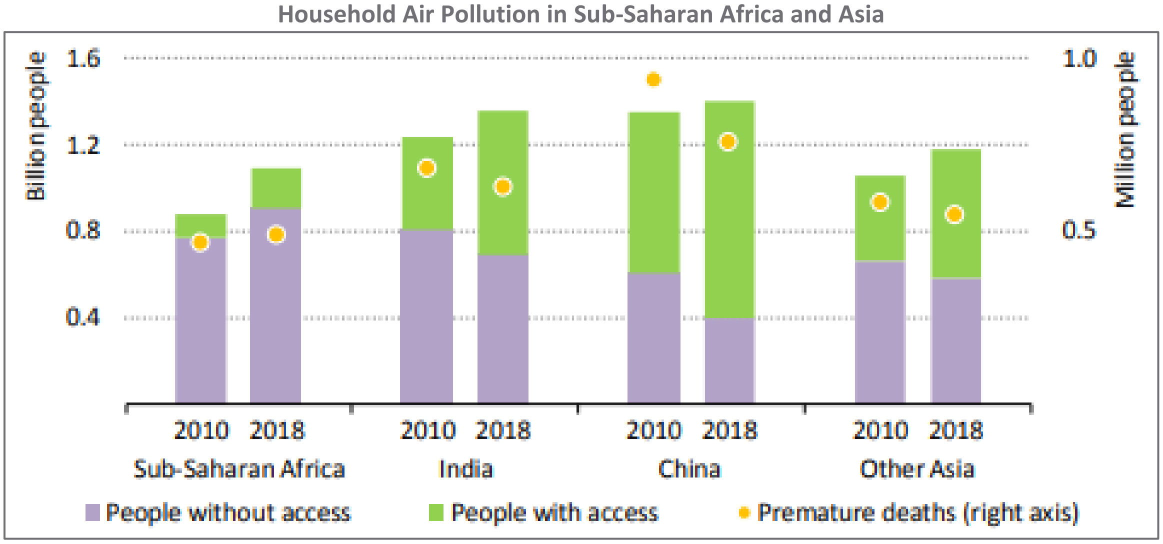


Sources: IEA; BTIG; HYDE (2016) & UN; WPP (2019)

Substandard access to energy derived from dirty, inefficient fuels crimps labor productivity and economic potential. It is also lethal. In 2018, almost 2.7 billion people, or 35% of the world's population, lacked access to clean cooking facilities, according to the IEA, resulting in almost 4 million deaths per annum attributed to indoor air pollution (WHO, 2019). For context, that is 11,000 people per day, or 450 people per hour.

Improvements in energy access are directly linked to reductions in mortality rates. However, premature deaths from household air pollution remains a global issue.

Access to Clean Cooking and Premature Deaths from Household Air Pollution in Sub-Saharan Africa and Asia



Source: IEA, World Energy Outlook Special Report, June 2020, p 77

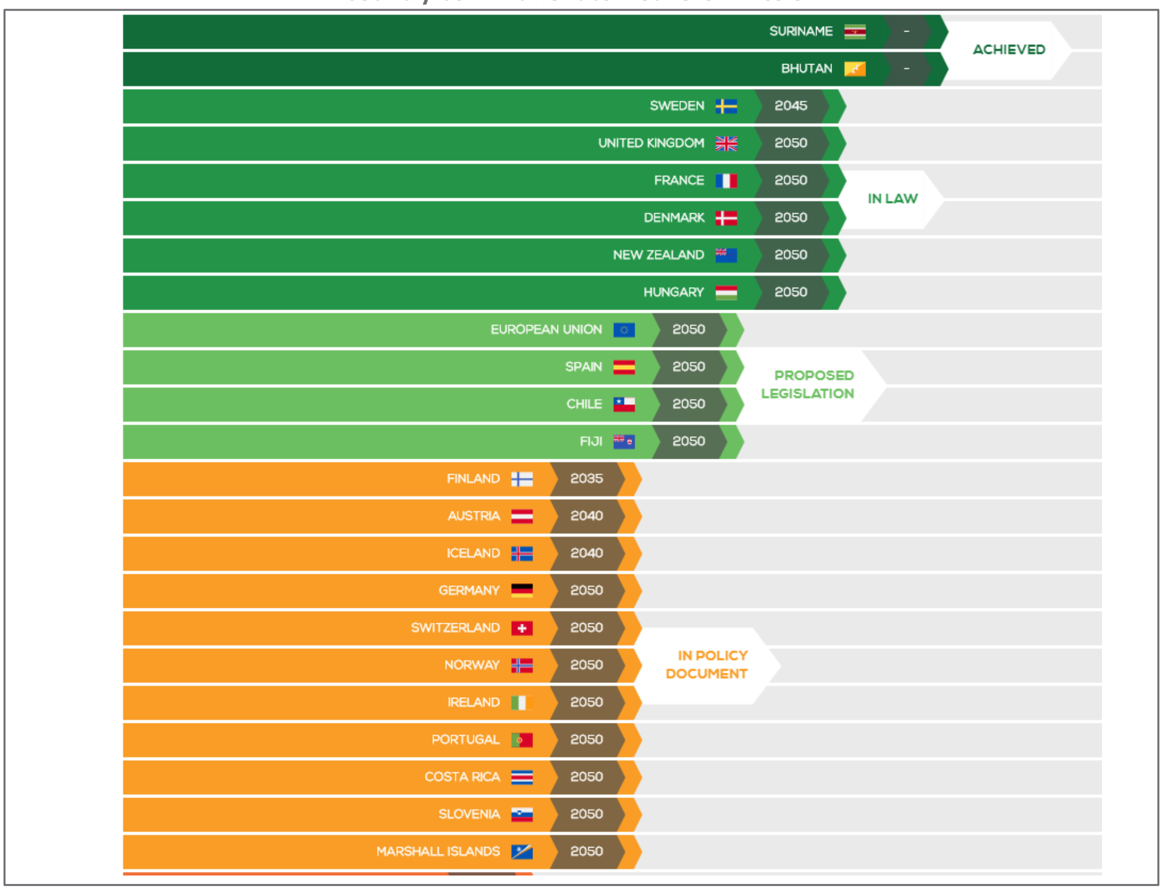
Human progress is reliant on access to energy. As emerging economies and populations grow, the energy transition provides a unique, self-fulfilling opportunity to address these stark inequalities while significantly reducing the environmental profile of the energy footprint, which in turn enhances economic productivity. In the IEA's recent report, the agency estimates that in addition to job creation and economic growth, the $1 trillion per year, three-year investment program would provide 420 million people with access to clean-cooking solutions and 270 million people with access to electricity[5].

The energy transition provides a unique, self-fulfilling opportunity to address stark inequalities and enhance economic productivity

Commitment

The combination of environmental, humanitarian, and economic imperatives has resulted in numerous governments around the world pledging to attain net zero emission status no later than 2050.

Country Commitment to Net Zero Emission



Source: Energy & Climate Intelligence Unit, Net Zero Tracker, Q2 2020

In fact, when large US states such as New York and California are included in the calculus, governments representing about 53% of global GDP have made the commitment or have a stated intention of doing so, according to the Energy & Climate Intelligence Unit. Clearly, momentum around the energy transition is growing.

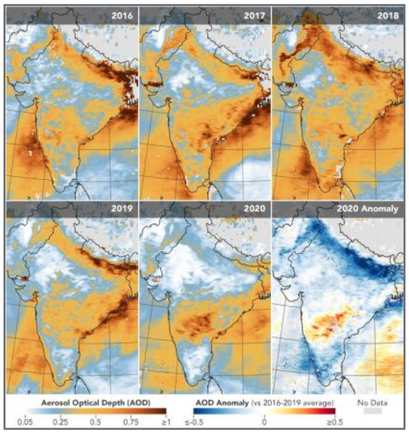
Governments representing ~53% of global GDP have made the commitment to attain net zero emission status by 2050 or have a stated intention of doing so

[5] Ibid

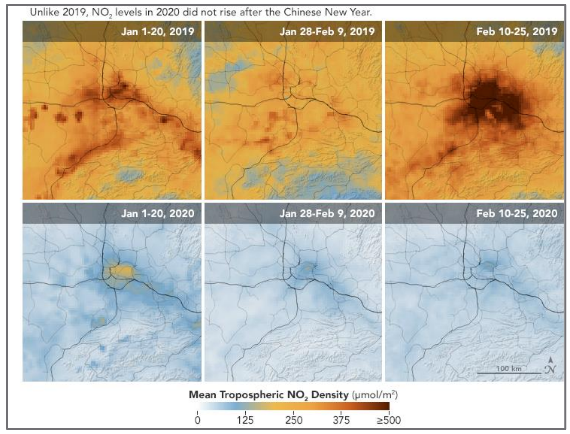
Lessons from COVID-19

Without downplaying the financial and health tragedies resulting from COVID-19, the sudden arrest of the global economy has provided some insight into how quickly the environment can heal, if given the chance.

Airborne Particle Levels – India



NOx Levels – Wuhan



Source: NASA Earth Observatory (www.earthobservatory.nasa.gov), Q2 2020

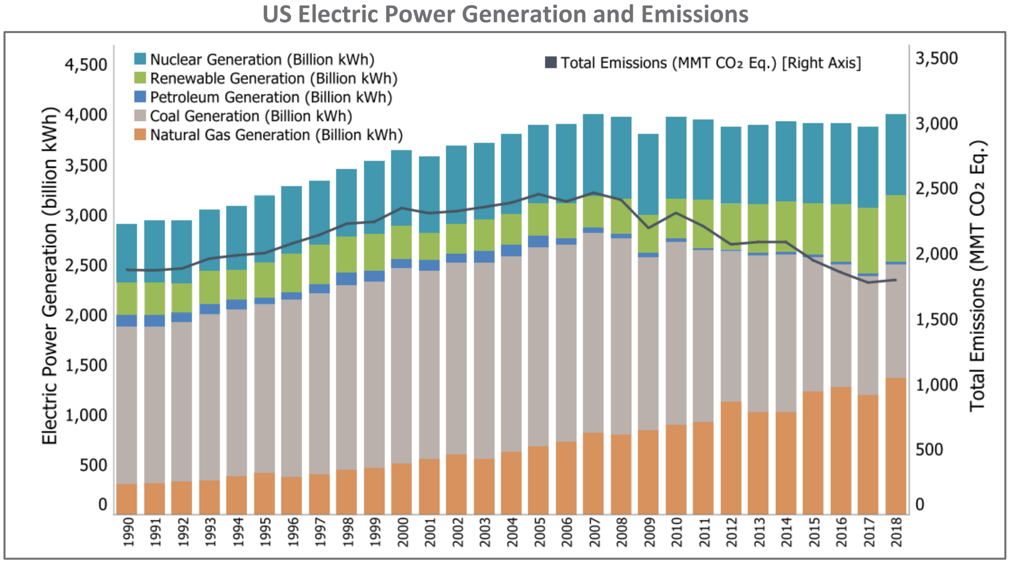
The IEA estimates that 2020 global $C0_2$ emissions may fall by more than 7.5% relative to 2019 levels. Given the current state of renewable technologies and the obvious need for economic growth and job creation, it may be that in retrospect, the one positive to have emerged from the current situation is that the pandemic helped accelerate the energy transition.

> *In retrospect, the one positive that may emerge from the COVID-19 pandemic is an acceleration of the energy transition*

Lessons from the US

A more prosaic and sustainable example of a large, installed hydrocarbon-based energy system continuing to support economic growth while significantly reducing carbon emissions is the United States. 2019 marked the lowest level of CO_2 emissions in more than a decade[6]. The primary driver of this improvement has been reductions in electricity related GHG emissions, which have declined by more than 25% over that time frame.

US Electric Power Generation and Emissions

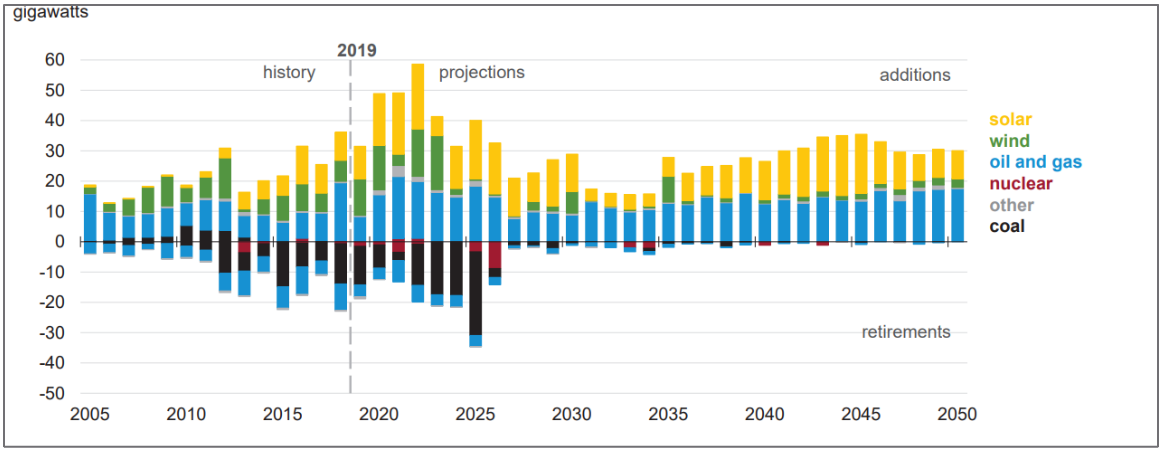


Source: EIA, *Inventory of US Greenhouse Gas Emissions and Sinks: 1990-2018*

[6] BP *Statistical Review of World Energy 2020,* June 2020

The reduction in electricity emissions is a function of natural gas, augmented more recently by renewables, taking share from coal. The forecast for future capacity additions is consistent with recent trends. Note that the projected "blue" additions are exclusively natural gas, not a mixture of gas and oil.

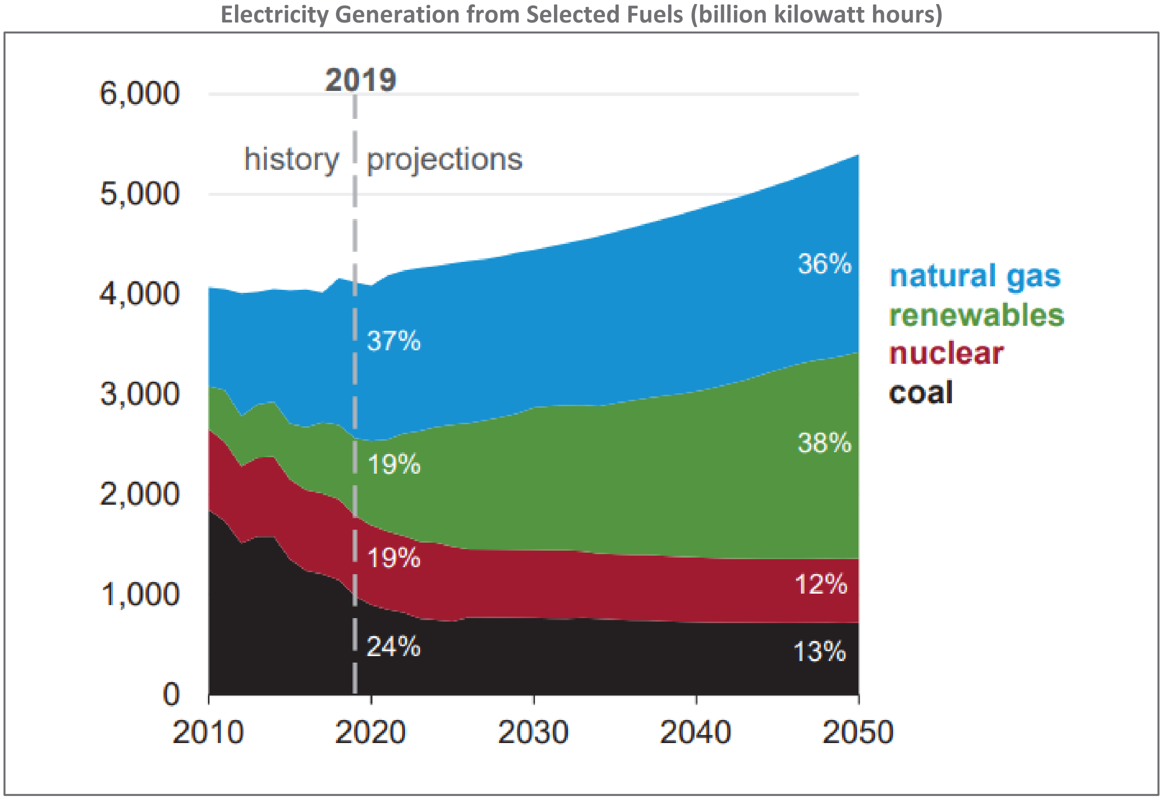
Annual Electricity Generating Capacity Additions and Requirements (Reference Case)



Source: U.S. Energy Information Administration, #AEO2020

By 2050, US energy consumption is expected to be 40% higher than today and will be supplied predominantly by natural gas and renewables.

Electricity Generation from Selected Fuels (billion kilowatt hours)



Source: U.S. Energy Information Administration, #AEO2020

The result will be a larger, more efficient energy base with a much smaller environmental profile.

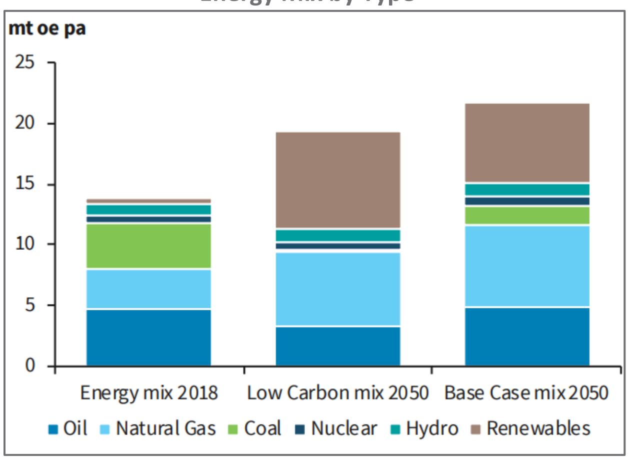
Summary

Whether the starting point is the largest economy or the fastest growing, the most developed country or the least, the energy transition is underway. We expect it to accelerate going forward as unit-level economics improve with technological advancement and scale, governmental and popular support increases and investment returns remain attractive.

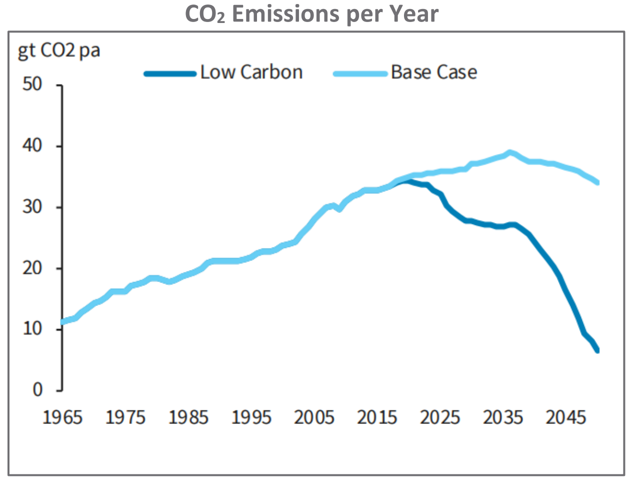
> *The only way to reduce the carbon footprint is to transition to an energy supply stack with no coal, less oil and a growing baseload of natural gas and renewables*

While undoubtably there will be twists and turns along the way, it's clear that the only way to reduce the carbon footprint while meeting the needs of a growing global economy and population is to transition to an energy supply stack with no coal, less oil and a growing baseload of natural gas and renewables, primarily in the form of electricity.

Energy Mix by Type



CO_2 Emissions per Year



Sources: BP Statistical Review; Barclays Research, Q1 2020

In summary, we expect natural gas and renewables to fuel the energy transition.

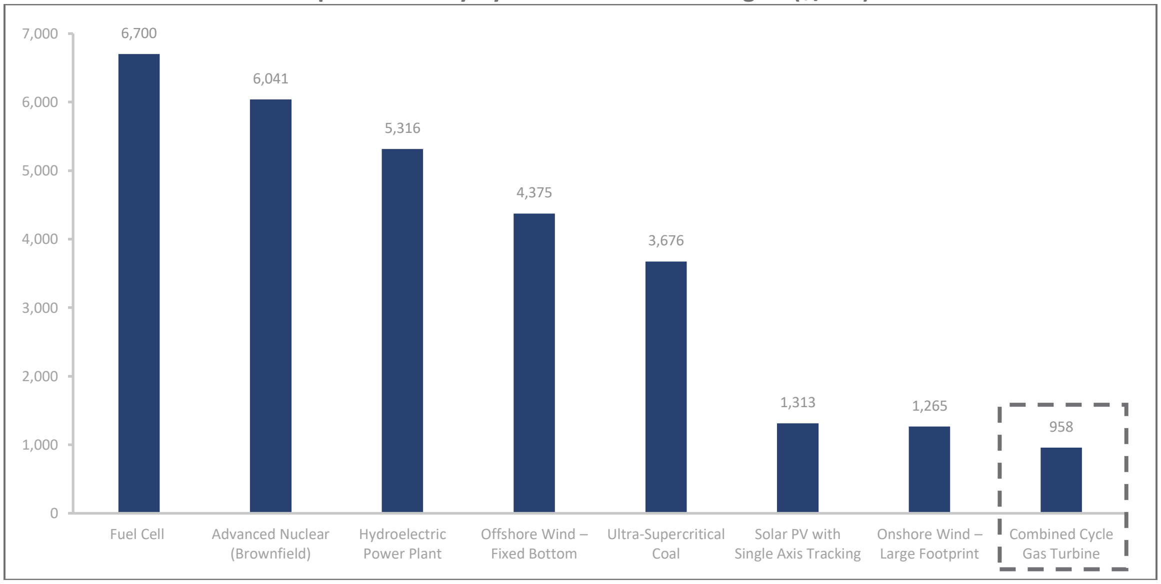
NATURAL GAS

Natural gas is an inexpensive, transportable fuel with high energy content, relatively low carbon footprint and a massive global network of distribution infrastructure and power generation.

From an electricity perspective, there are over 1.6 terawatts of installed natural gas-fired capacity world-wide, 24% of the total. Running at a 40% capacity utilization rate, or load factor, natural gas-fueled power plants produced about 23% of total electricity in 2019. Coal, on the other hand, has an installed capacity of 2.1 terawatts, 30% of total capacity, and produced 34% of global electricity in 2019, running at a 46% utilization rate. While it is a gross oversimplification, if the capacity factor of existing natural gas plants was increased from 40% to 50% and all of that power displaced coal, total global CO_2 emissions would have fallen by 4.3% in 2019, assuming that gas-fired power has 50% of the CO_2 emissions as coal. This represents almost 60% of the reduction in $C0_2$ emissions related to the COVID-19 pandemic, would require limited investment and would be a permanent, structural elimination. Clearly there is room to leverage the existing natural gas power supply.

In addition, gas-fired power plants are relatively quick to construct, have a small form factor and are the most capital efficient of any utility-scale generation technology.

Capital Intensity by Generation Technologies ($/kW)



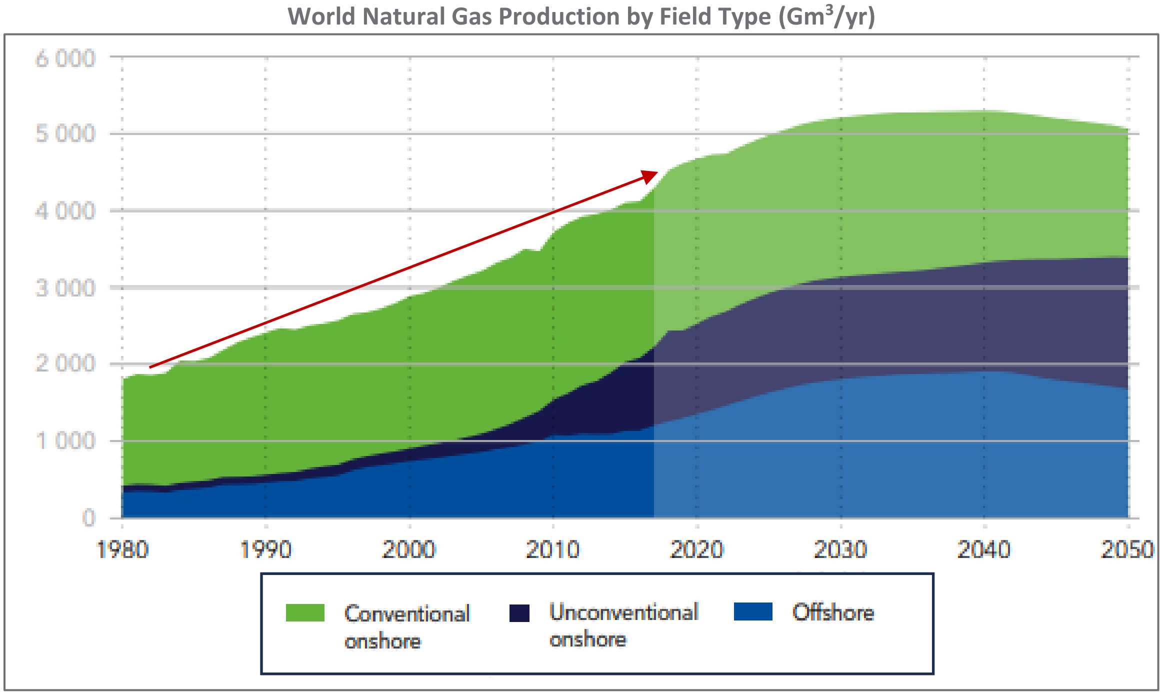
Source: US Energy Information Administration, Capital Cost and Performance Characteristic Estimates for Utility Scale Electric Power Generating Technologies, February 2020

The cost-effective and scalable nature of combined cycle gas turbines means that natural gas is a logical fuel source for both developed and developing economies. As a result, natural gas-fired power capacity is expected to approximately double in the next 30 years.

Natural gas fired power capacity is expected to approximately double in the next 30 years

If natural gas ends up playing as pivotal a role as we expect in the energy transition, the question then becomes one of supply. Fortunately, natural gas is a relatively abundant, inexpensive fuel source which, when combined with its much lower carbon footprint, helps explain the surge in natural gas demand over the last forty years.

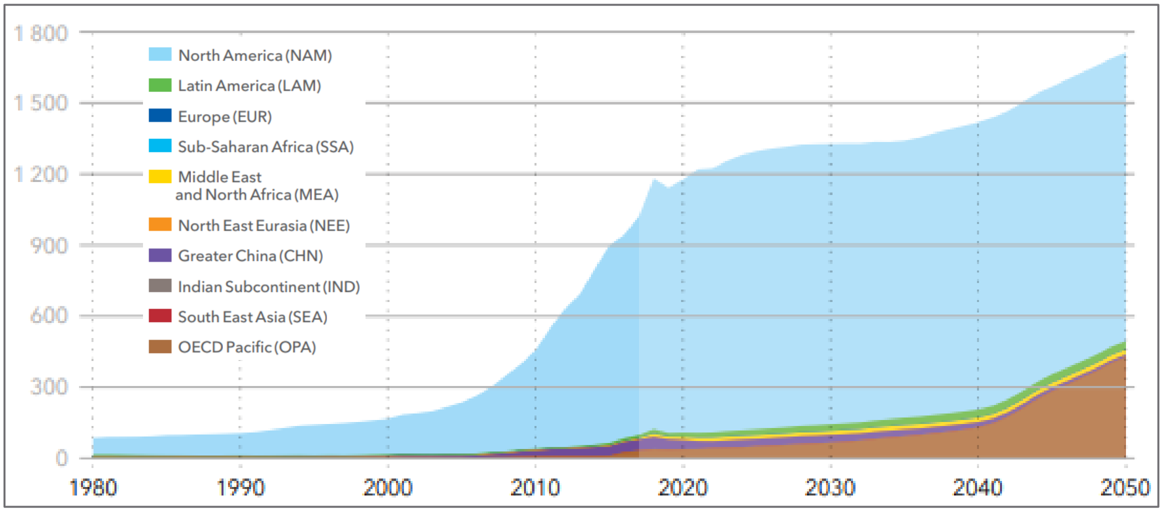
World Natural Gas Production by Field Type (Gm³/yr)



Note: Includes natural gas liquids from wells, but not refinery outputs. Historical data source: Rystad (2019)
Source: DNV-GL *Energy Transition and Outlook 2019, Oil and Gas*

Much of the historic supply growth has come from offshore developments primarily linked to LNG export facilities. More recently, unconventional onshore has assumed the growth mantle, and going forward is expected to meet the bulk of incremental demand. This is highly relevant since the vast majority of those unconventional onshore resources reside in North America.

Unconventional Onshore Natural Gas Production by Region (Gm^3/yr)

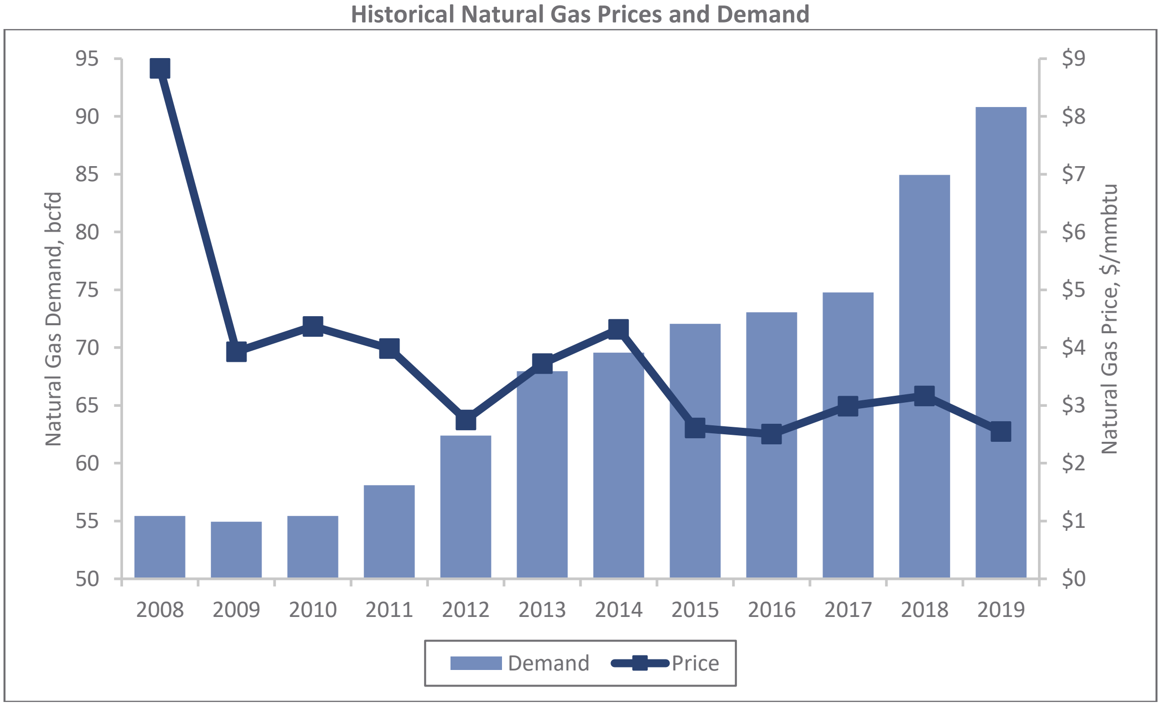


Note: Historical data source: Rystad (2019)
Source: DNV-GL *Energy Transition and Outlook 2019, Oil and Gas*

In fact, it is quite reasonable to state that North America, and particularly the United States, is the Saudi Arabia of natural gas.

Many investors have dismissed natural gas, confusing the significant increase in production/demand and decline in marginal costs as being indicative of a limitless, almost zero-cost fuel.

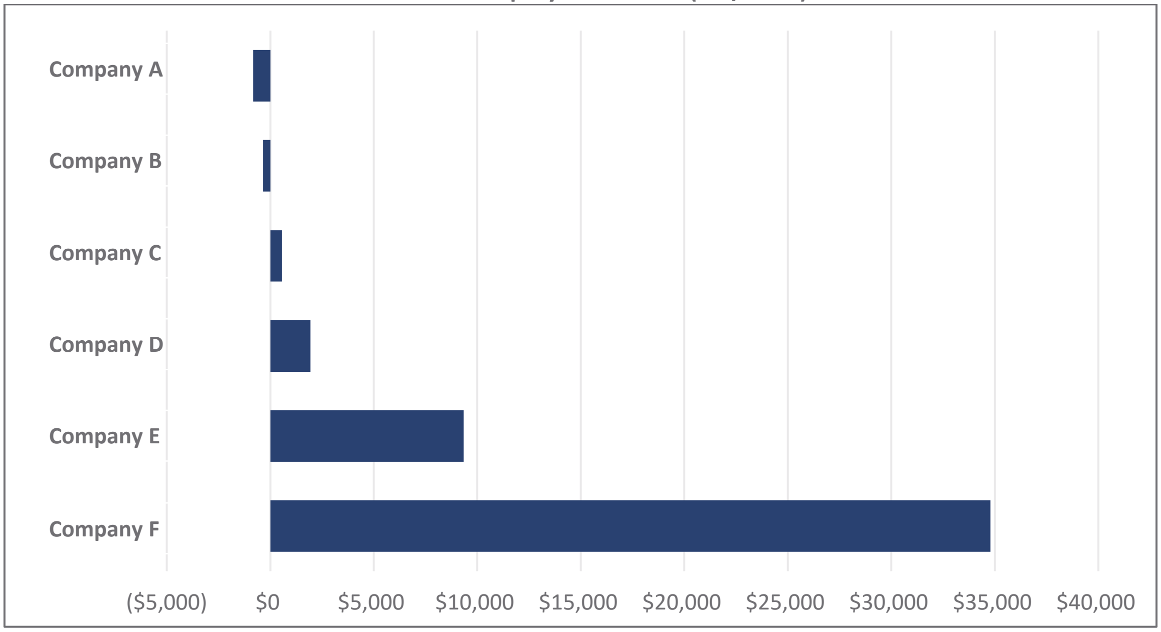
Historical Natural Gas Prices and Demand



Source: U.S. EIA, FactSet, Q2 2020

This has flowed through to natural gas equity valuations, where most companies trade as if their undrilled inventory is worthless.

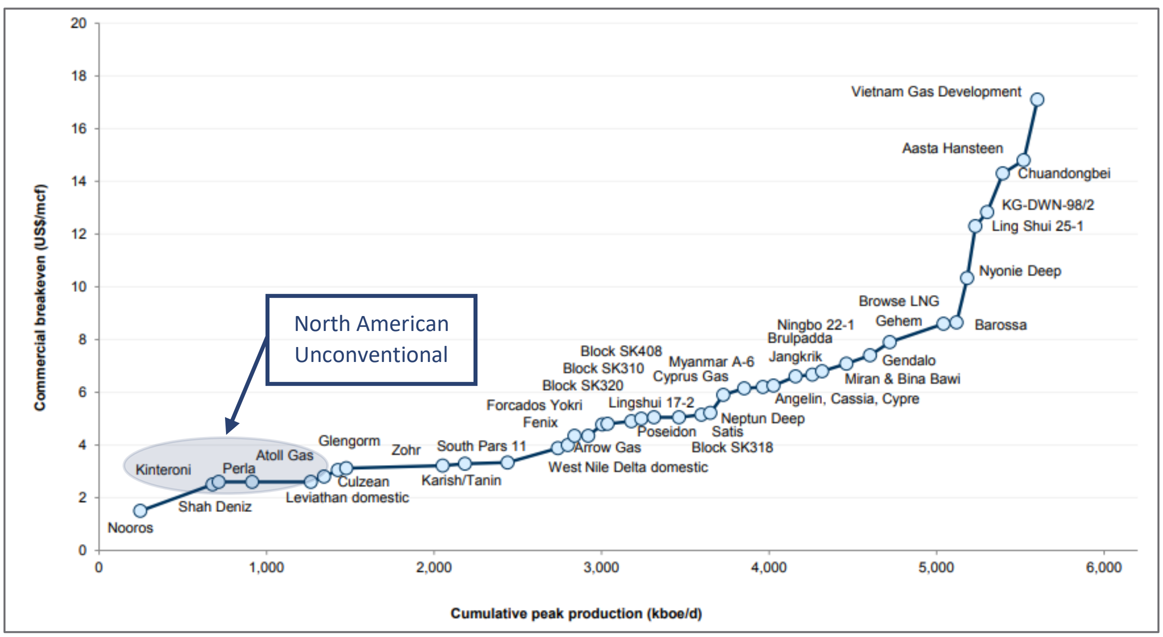
Natural Gas Equity Valuations (EV / Acre)



Source: Company filings, SSCP analysis, Q2 2020

The reality is that the global cost curve for natural gas is quite steep, and that the North American unconventional plays dominate the bottom end of that curve.

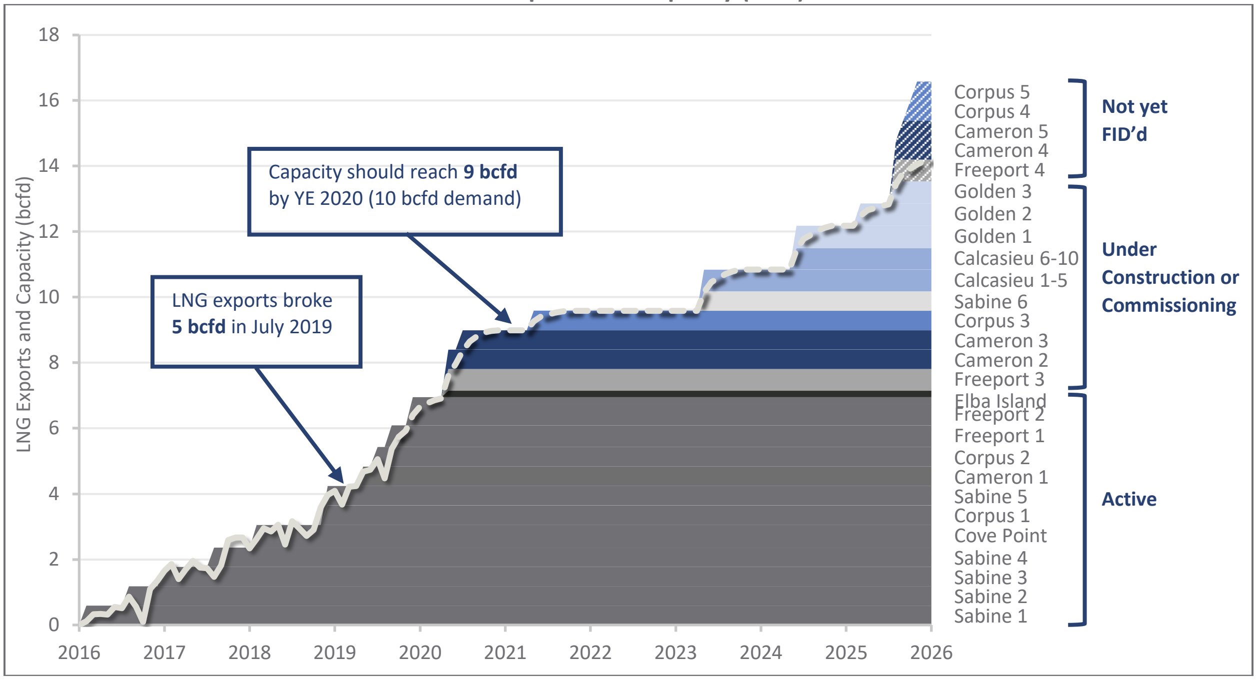
Global Natural Gas Cost Curve



Source: Goldman Sachs, *Top Projects 2020,* May 20, 2020

Consistent with the reflexive nature of commodity markets, the decline in commodity prices was driven by the emergence of very low-cost, capital-efficient shale plays such as the Marcellus, which in turn has created the incentive for incremental demand. North America is now tied into the global gas market as the result of the significant increase in LNG export capacity, which is expected to grow going forward.

LNG Exports and Capacity (bcfd)

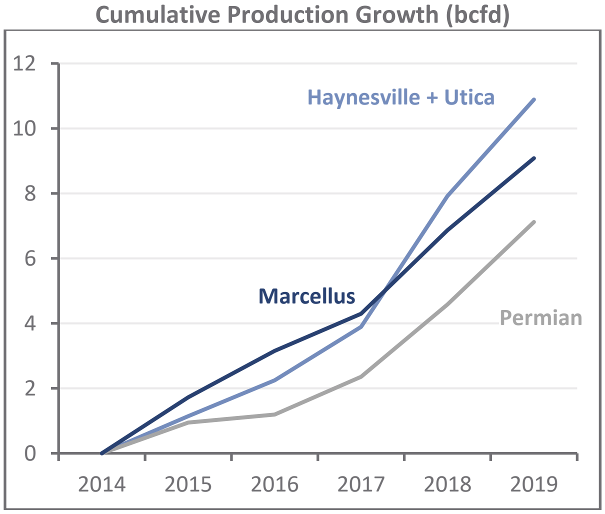


Sources: U.S. EIA; SailingStone Capital Partners LLC, Q2 2020

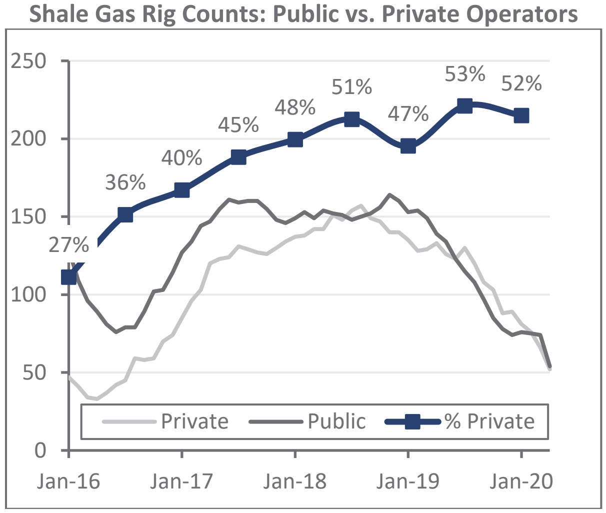
These are multi-billion dollar projects backed by multi-decade purchase agreements. Clearly, natural gas, and particularly North American natural gas, is viewed as an increasingly critical component of global energy supply.

It is true that more recently the North American gas markets have become temporarily oversupplied, driven in large part by the massive overcapitalization of higher cost unconventional oil and natural gas assets by private equity firms following the 2014/2015 energy crisis.

Cumulative Production Growth (bcfd)



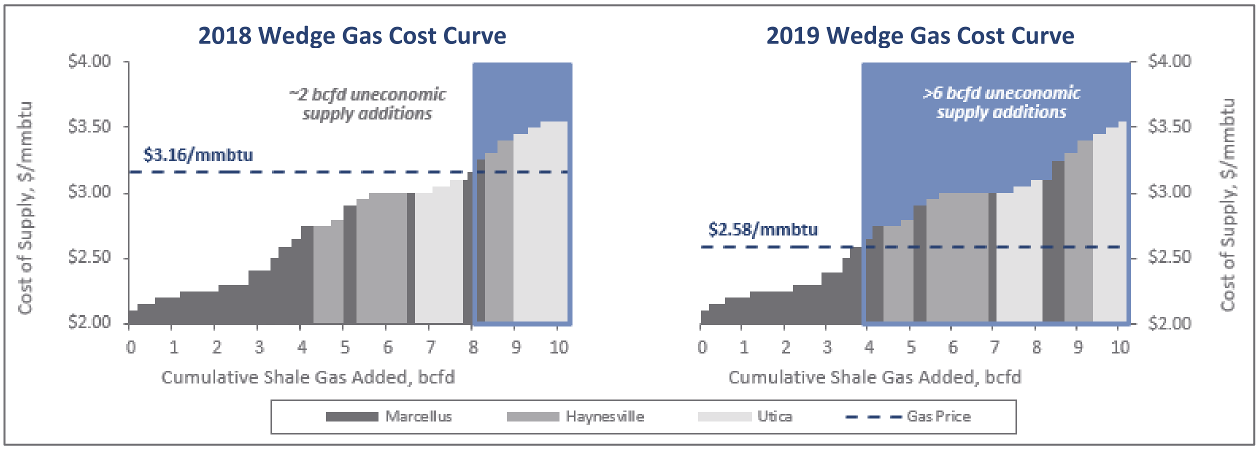
Shale Gas Rig Counts: Public vs. Private Operators



Sources: SSCP White Paper "The Crucible Report," Nov 2019; DrillingInfo, Q2 2020

This resulted in significant increases in uneconomic production from the Haynesville and Utica shale plays, particularly in 2019.

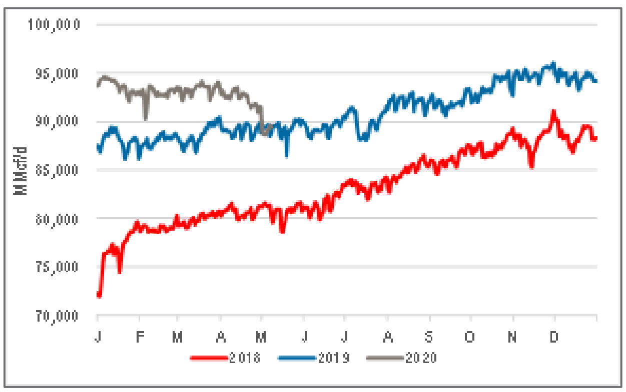
Wedge Gas Cost Curve



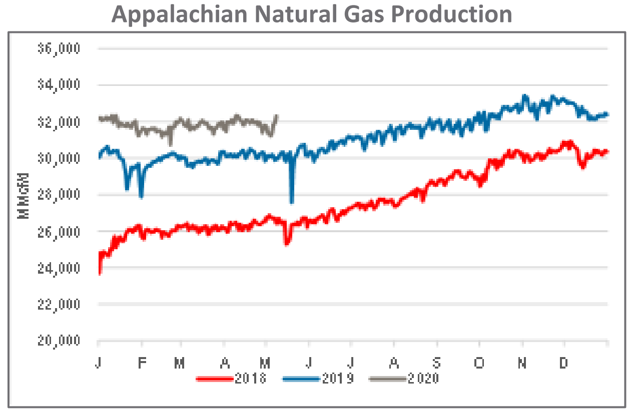
Source: SSCP White Paper “The Crucible Report”, Nov 2019; SSCP White Paper “Shale Gas Inventory: Problem or Opportunity?”, Mar 2019

Fortunately, this is being reversed as rig counts fall and production across all but the most economic basins follows suit.

L48 Natural Gas Production



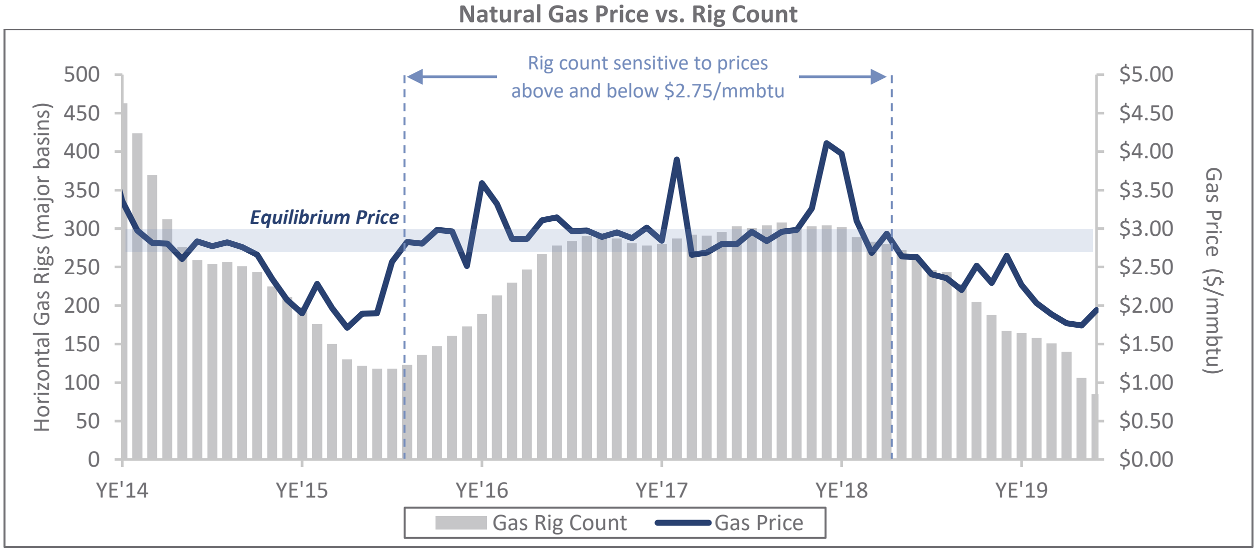
Appalachian Natural Gas Production



Source: JP Morgan and Genscape, May 11, 2020

Numerous analysts have claimed that there is an endless supply of North American natural gas that works at $2.50/mcfe and below. The rig count tells a different story, suggesting that industry break-even prices have been between $2.75-$3.00 for the last several years.

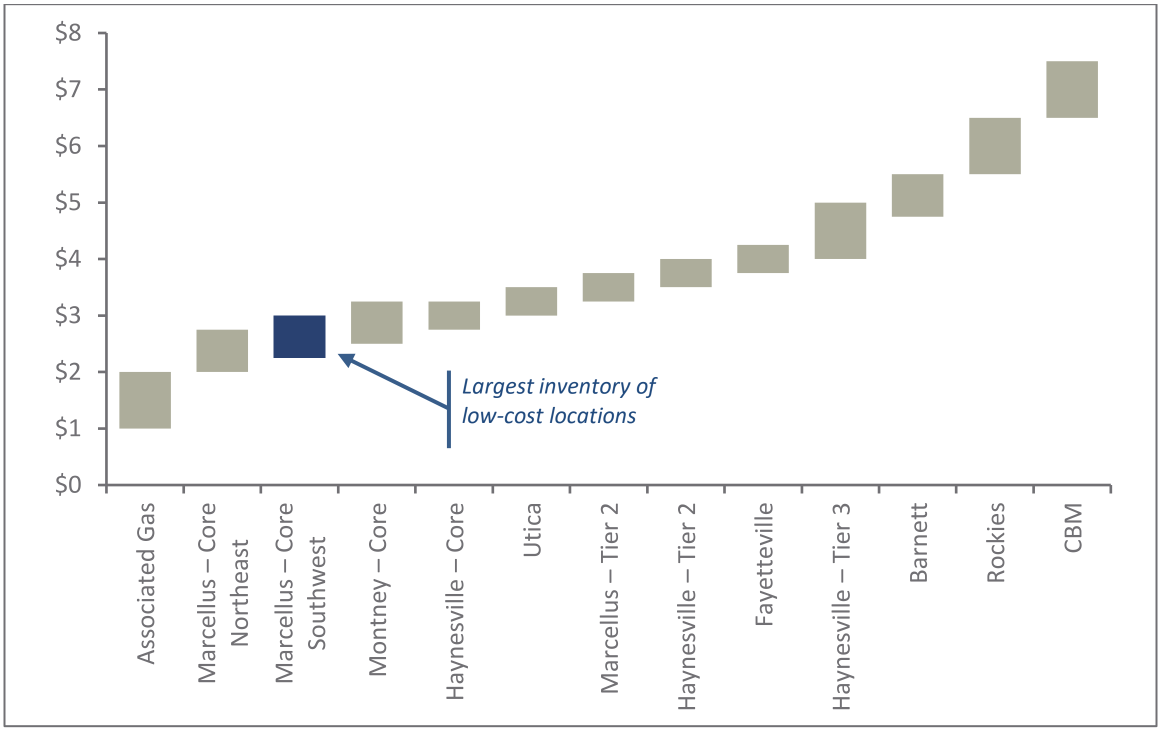
Natural Gas Price vs. Rig Count



Sources: DrillingInfo, Q2 2020; FactSet, Q2 2020

However, this price construct is likely to change going forward, and not for the better. To understand the dynamics at play, it is worth examining the cost curve in more detail, with a particular focus on the area with the largest inventory of low-cost gas wells, North America.

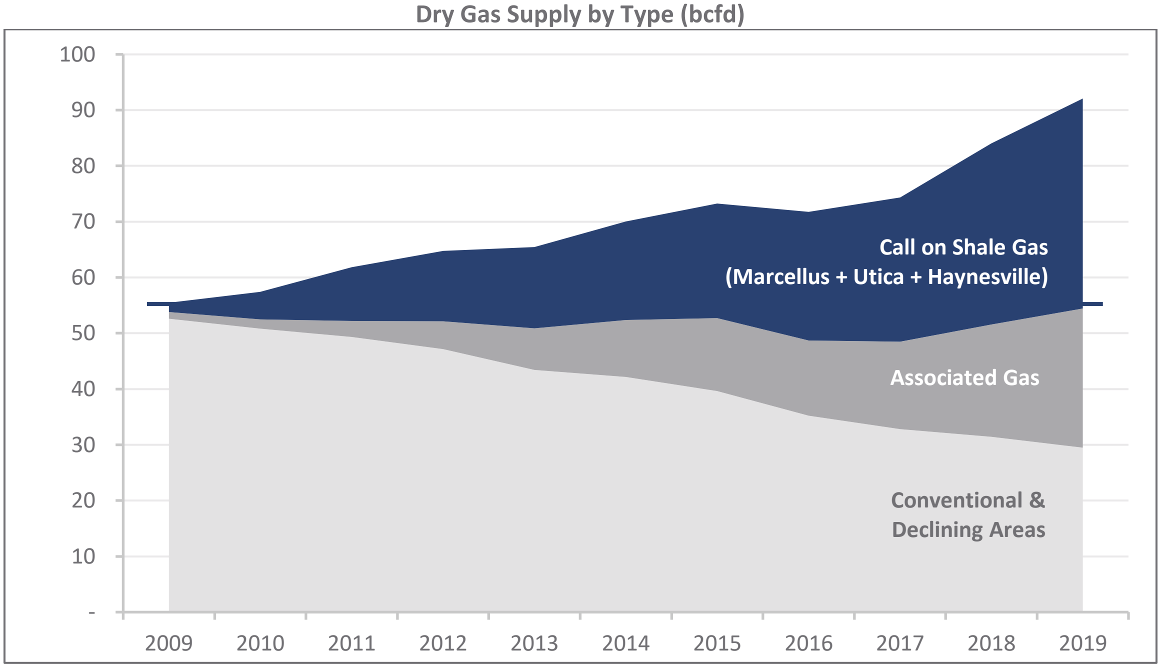
North American Natural Gas Cost Curve



Sources: SSCP analysis, Company information, Q2 2020

Obviously, associated gas sits at the bottom of the curve as it is a by-product of oil drilling. When oil was a $50-$70/bbl commodity, associated gas was regarded as a necessary evil. While many viewed this low-cost supply as the bogeyman for the natural gas market, the reality is that until the end of 2019, associated gas production merely offset underlying declines from conventional production.

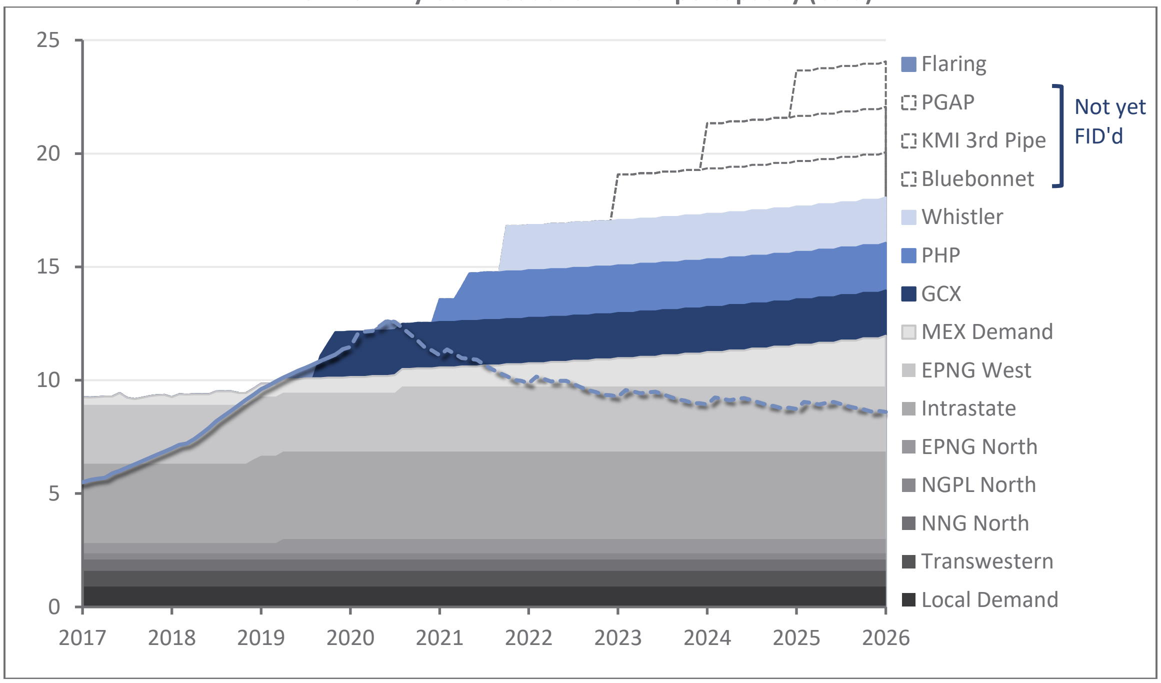
Dry Gas Supply by Type (bcfd)



Source: SSCP White Paper "The Crucible Report", Nov 2019; SSCP White Paper "Shale Gas Inventory: Problem or Opportunity?", Mar 2019

Today, with a plummeting oil rig count and a severe rationing of capital, it seems unlikely that associated gas will overrun the North American markets in the foreseeable future. In fact, absent a significant reacceleration of drilling activity, it appears that many associated gas pipelines will struggle to fill capacity.

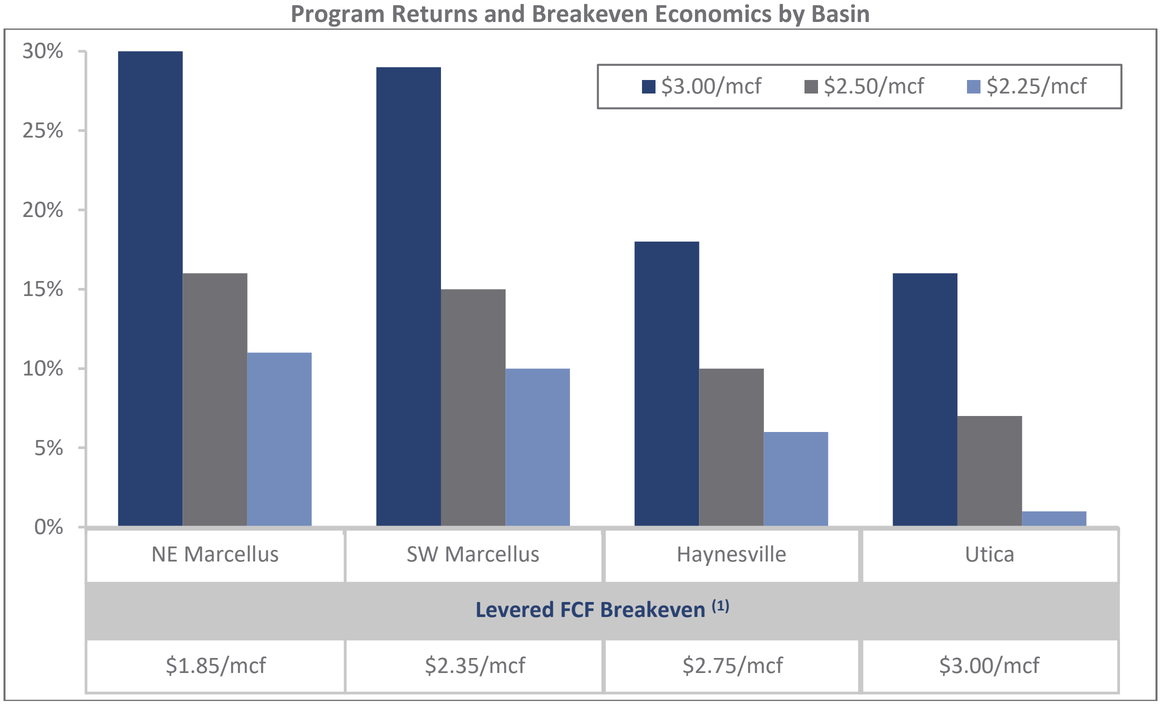
Permian Dry Gas Production and Pipe Capacity (bcfd)



Sources: SSCP White Paper "The Crucible Report," Nov 2019; U.S. EIA, Q2 2020

This, then, leaves shale gas as the key component of incremental North American supply. An analysis of basin-level economics supports the conclusion drawn from the rig activity/gas price chart above – higher cost basins such as the Haynesville and Utica need gas prices between $2.75-$3.00 to generate cash-on-cash program returns of 15-20%, which would approximate corporate break-evens.

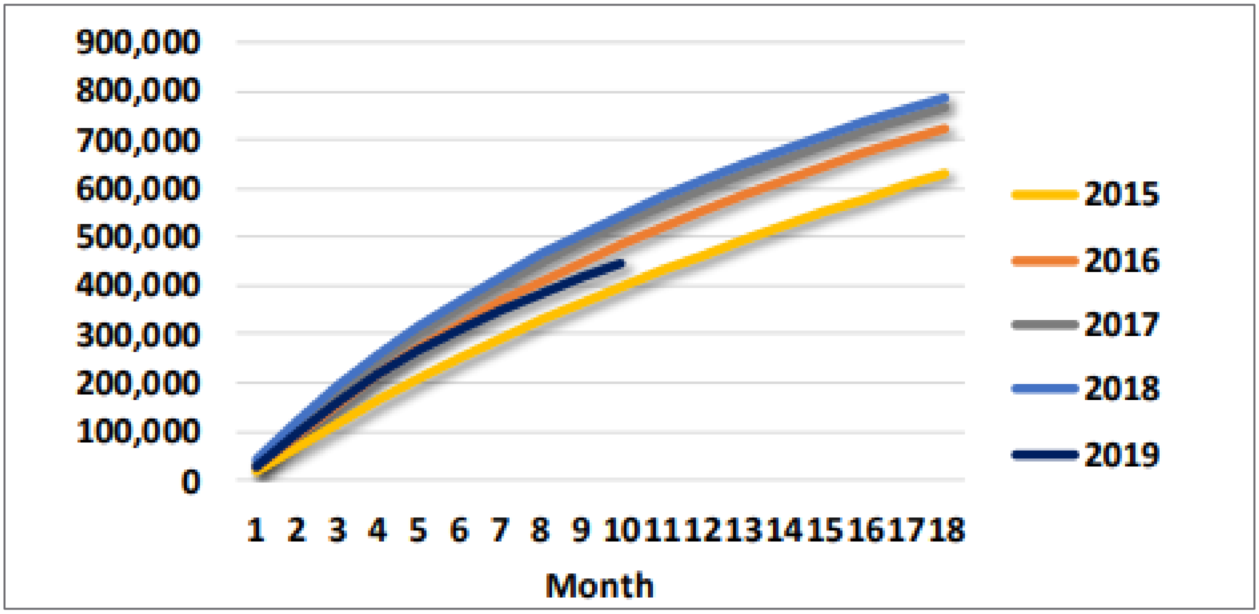
Program Returns and Breakeven Economics by Basin



(1) Gas price required to keep production flat in a basin (assuming $55/bbl crude)
Sources: SSCP analysis, Company information, Q2 2020

Unfortunately, the area with the most attractive economics, the NE Marcellus and in particular the well-defined dry gas core in Susquehanna county, is reaching maturity. This is evident by looking at well performance over time, which shows a steep degradation as Tier I Lower Marcellus inventory is depleted, forcing operators to develop less prospective acreage and drilling horizons.

Susquehanna Well Productivity (Mcf/1000 ft)



Source: USCA, Annual Productivity Chartbook 2020, June 2020

This is consistent with SailingStone's detailed analysis of remaining inventory when grouped by economic break-even.

Remaining Economic Inventory [1] by Play and Breakeven Gas Price

Region	<$2.50	$2.50 to $3.00	>$3.00	Total
NE Marcellus	308	816	2,367	3,491
SW Marcellus	1,422	2,296	2,248	5,966
Utica	--	--	3,479	3,476
Total Appalachia	**1,730**	**3,112**	**8,091**	**12,933**
Haynesville	--	879	1,225	2,104
Total Core	**1,730**	**3,991**	**9,316**	**15,037**
% of Total	*12%*	*27%*	*62%*	*100%*

Roughly five years of core inventory remaining below $3/mcf

(1) Inventory counts normalized to 10,000'.
Source: SSCP White Paper "The Crucible Report", Nov 2019; SSCP White Paper "Shale Gas Inventory: Problem or Opportunity?", Mar 2019

North America is blessed with a massive endowment of low-cost natural gas relative to the rest of the world. However, it is quite evident from a review of the data that core inventory is, by definition, finite and that over the next three to five years less economic inventory will require higher natural gas prices to be developed.

From a commodity perspective, we contend that North American natural gas sits in a sweet spot and is likely to remain there for many years into the future. The energy transition will occur on the back of natural gas, and global demand is expected to grow as existing power generation capacity is run at higher utilization rates and new capacity is installed. The cost curve is steep, and North American assets dominate the bottom end of the curve. Increasingly, North America will be tied into the global market via LNG export capacity, which continues to grow.

While there may be a limited number of wells which generate economic returns much below $3.00/mcfe, there is a decade plus of incremental inventory which works between $3.00-$4.00. This compares very favorably with the rest of the world.

North American natural gas benefits from structural demand tailwinds based on proven technologies and installed capacity which together help increase a global good

This, then is the Goldilocks' scenario for any commodity – structural demand tailwinds based on proven technologies and installed capacity which together help increase a global good (more access to cheap, cleaner electricity), combined with supply that is derived from a steep cost curve where the most attractive reinvestment opportunities reside in stable, supportive jurisdictions with significant existing infrastructure available to be leveraged.

From an investment perspective, the prospects are even brighter. To reiterate, North American natural gas sits at the bottom of a steep global cost curve. This is the most important point for any long-term investor considering an allocation to natural resource equities, equivalent to real estate's maxim "location, location, location." Furthermore, the intra-North American cost curve is quite steep as well. The core areas of the North American gas basins are largely consolidated and are being managed by companies who have been forced to live within their own cash flows for much longer than their shale oil peers. The result is that underlying depletion rates are lower and cost structures have been rationalized. Thus, free cash flow generation and the prospects for a return of that free cash flow is meaningful, particularly for companies that own long-lived, low-cost inventory. Remarkably, for many companies, that inventory effectively is available for free today despite the prospects of double-digit free cash flow yields at current depressed commodity prices.

For investors focused on participating in and capitalizing on the energy transition, we believe that the opportunity in North American natural gas is one of the most compelling that we have seen in the last 20 years. While some institutions have used the blunt instrument of divestment to eliminate all hydrocarbons from their portfolio, reality is far more nuanced. In fact, when viewed empirically, it is quite clear that natural gas is one of the key enablers of the energy transition.

The opportunity in North American natural gas is one of the most compelling that we have seen in the last twenty years

Undercapitalizing natural gas will result in higher, more volatile power prices, a significant reduction in the pace of expanded energy access in developing regions and a far longer and more capital-intensive journey towards a lower carbon global economy. These outcomes seem to run counter to the stated objectives of many capital providers who are financing the energy transition. Fortunately, today there is the opportunity to generate extremely attractive returns while supporting the journey to a zero-emission future.

COPPER

The second commodity whose role in the energy transition is still not appreciated by investors is copper. While natural gas is a critical but definitionally interim participant, copper is ubiquitous across virtually all technologies related to a lower carbon world.

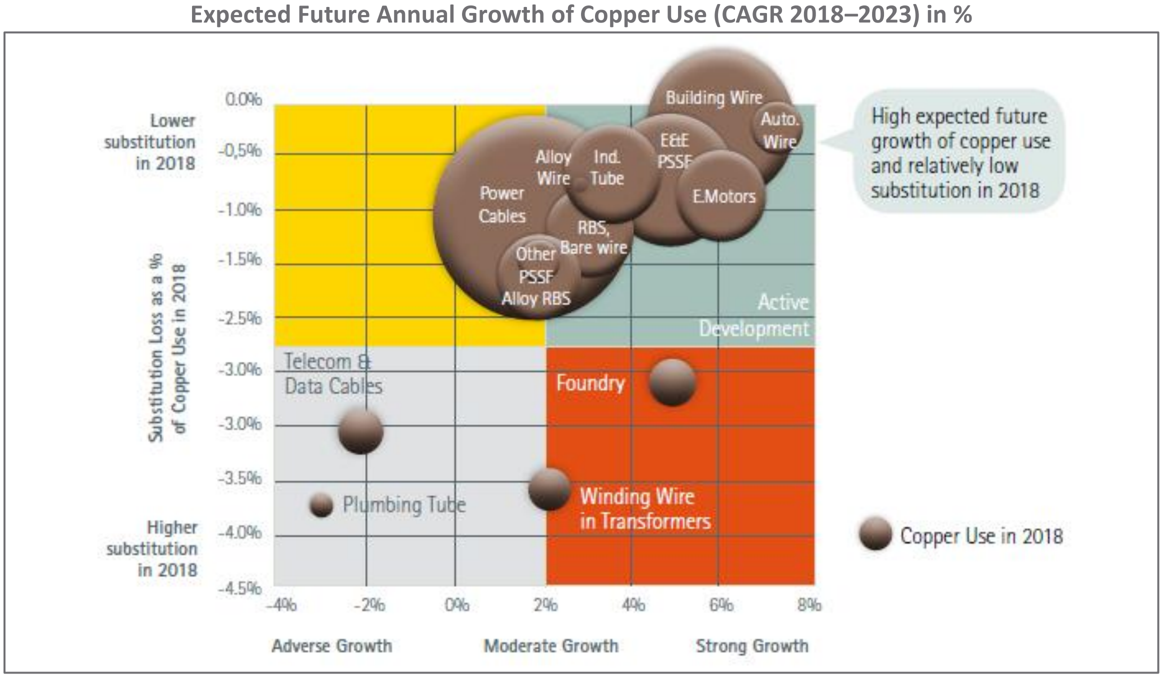
Renewables and EV's Mined Metal Requirements

	Cobalt	Copper	Dysprosium	Gallium	Indium	Lithium	Neodymium	Nickel	Platinum	Selenium	Silver	Tellurium
Reserve (ton)	7,100,000	790,000,000	55,000	5,200	47,100	16,000,000	4,100,000	74,000,000	44,100	100,000	530,000	31,000
Mining (ton/year)	110,000	19,700,000	1,350	555	720	43,000	21,000	2,100,000	200	3,300	25,000	420
Recycling rate (current)	40%	60%	15%	15%	40%	10%	15%	60%	70%	5%	80%	0%
Metal intensity (ton/GW)												
Wind power (induction)		4,982						377				
Wind power (PM)		4,700	13				200	377				
Solar PV (Si)		884									10	
Solar PV (aSiGe)		1,005			5.32							
Solar PV (CdTe)		5,181										70
Solar PV (CIGS)		450		4	13					41		
CSP (parabolic)		3,200						940			13	
CSP (central power)		1,400						1,800			16	
Metal intensity end use												
Motor PM (kg/kW)		0.19835	0.0000516				0.0038					
Motor induction (kg/kW)		0.48105										
Battery (kg/kWh)	0.4	0.4				0.2		0.6				
Fuel cell (kg/kW)									0.00015			

Source: Manberger, Stenqvist, Energy Policy 119, 2018

Current demand is already beginning to reflect copper's unique physical and technical characteristics.

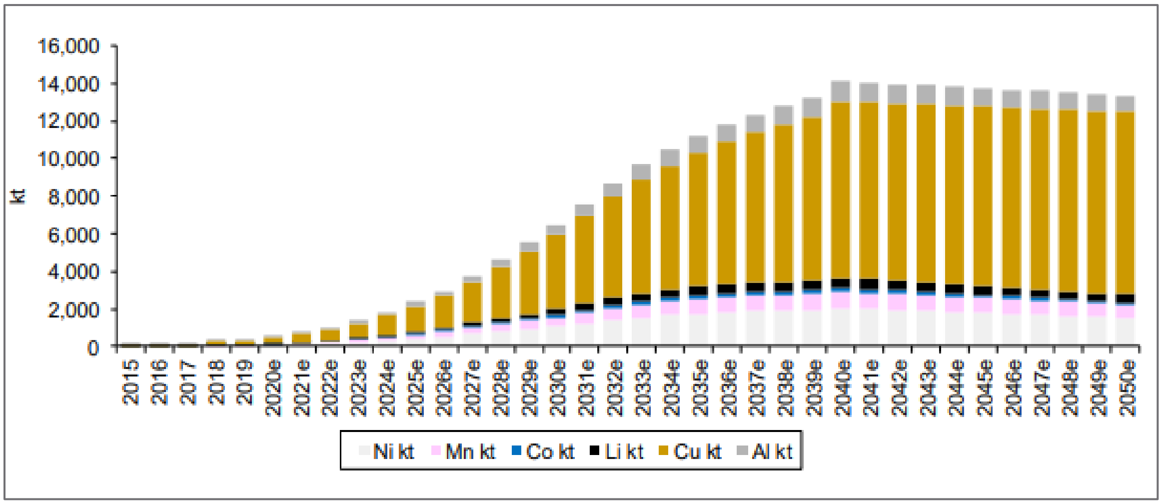
Expected Future Annual Growth of Copper Use (CAGR 2018–2023) in %



Source: CRU, Q2 2019

As it relates to the energy transition, most of the focus on incremental copper demand is related to electric vehicles ("EV"). Copper is by far the biggest beneficiary of incremental EV penetration on an absolute basis.

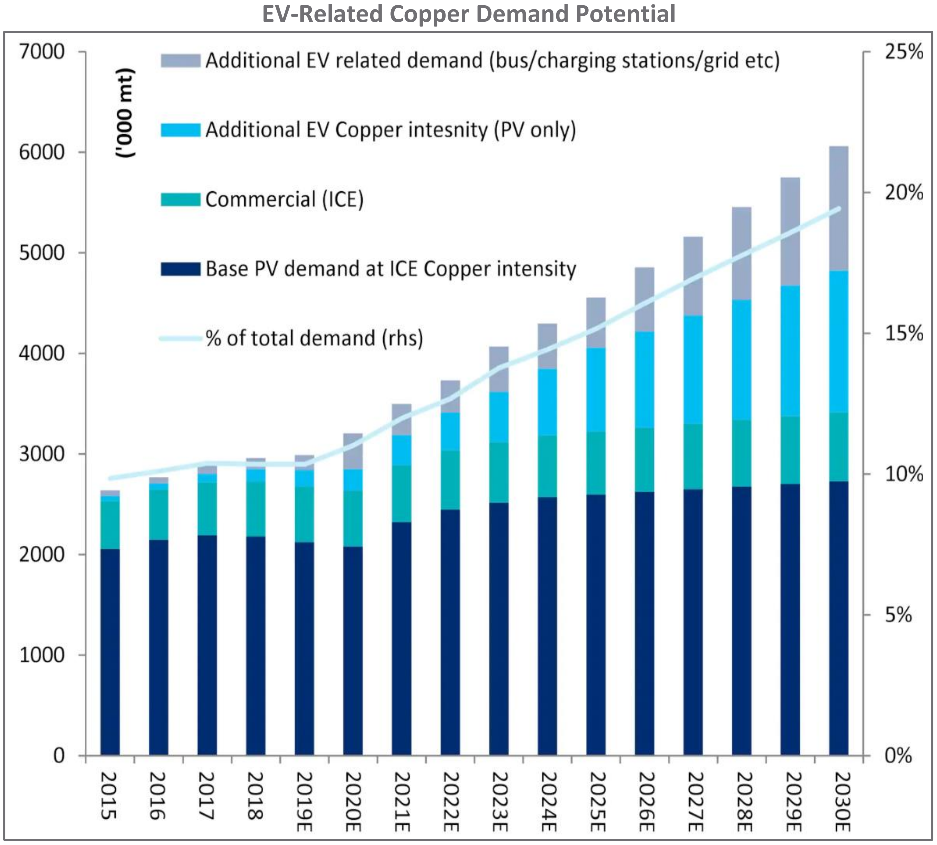
Metals Demand from EVs (Government Targets)



Source: Bernstein Research, Electric Revolution 2020

More importantly, demand from EVs alone could reach around 15% of current annual mined copper production by 2030, and as much as 40% by 2040 given the significantly higher copper content of EVs relative to internal combustion vehicles ("ICE").

EV-Related Copper Demand Potential



Source: Citi Electric Vehicle Metals and Equities Outlook, 9/8/19

But the copper intensity of EVs relative to ICEs is only one part of the demand outlook. Renewables also require an order of magnitude more copper than conventional power sources.

Copper Intensity

Coal/Nuclear	Solar	Onshore Wind	Offshore Wind
1 t/mW	5 t/mW	5.4 t/mW	15.3 t/mW

Increasing Copper Intensity

Sources: Bernstein; Wood Mackenzie; SailingStone Capital Partners, Q2 2019

Assuming a 70/30 split between onshore and offshore wind by 2050 and the copper intensities referenced above, we can estimate the impact of future renewable installations on copper demand using the EIA's reference case forecast for installed capacity by generation source.

Impact of Renewable Installations on Copper Demand

	2019	2050	Delta	Cu Intensity (t/mW)	Incremental Cu Demand (mm t)
Installed Wind Capacity (gW)	604	2,408	1,804		
Onshore			1,263	5.4t/mW	6.82
Offshore			541	15.3t/mW	8.28
Installed Solar Capacity	596	3,927	3,331	5.0t/mW	16.66
				Total	**31.75**
				vs 2020 Mine Production (~20mm t)	***159%***
				CAGR	***3.2%***

Source: EIA International Energy Outlook 2019, Sept 2019

To provide an idea of the sensitivity to a more aggressive renewables roll-out, we used the same process based on the IEA's *Renewables 2019* accelerated case for the period 2019-2024.

Impact of Renewable Installations on Copper Demand: Accelerated Case

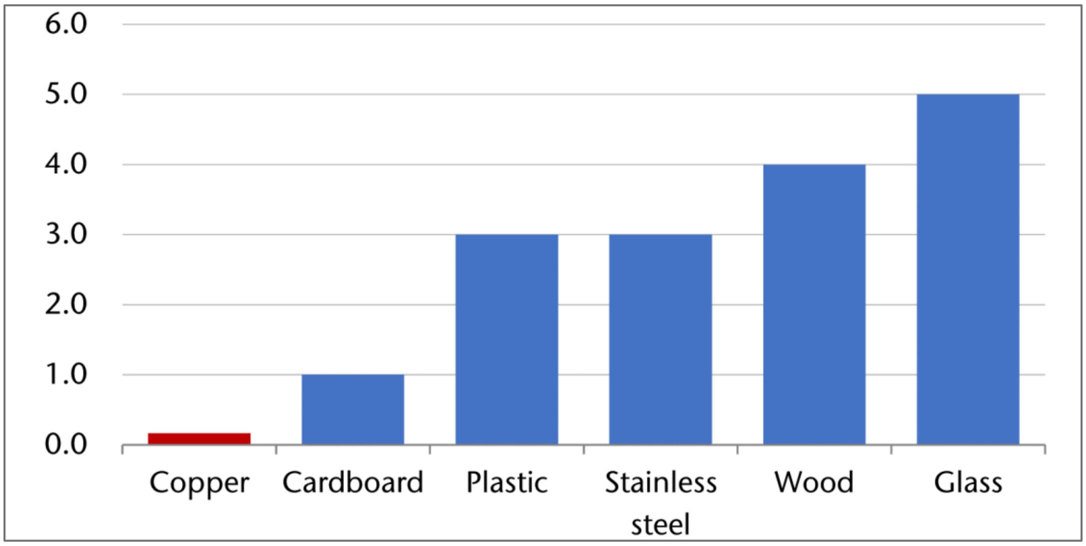
	2019-2024	Cu Intensity (t/mW)	Incremental Cu Demand (mm t)
New Onshore Wind (gW)	377	5.4t/mW	2.04
New Offshore Wind (gW)	54	15.3t/mW	0.83
New Solar (gW)	877	5.0t/mW	4.39
		Total	**7.25**
		vs 2020 Mine Production (~20mm t)	***36%***
		CAGR	***8.0%***

Source: IEA Renewables 2019, Oct 2019

For context, copper demand has averaged about 2.5% per year for the last century. The reference case requires a supply base that was 200 years in the making to more than double in the next 30 years. The more "progressive" forecast almost triples the amount of supply growth needed to meet renewable capacity installation targets over a much shorter time frame. Critically, none of these estimates include any grid stabilization/expansion or tie-in infrastructure investments which will be required to connect renewable generation with demand centers.

One final property of copper which receives almost zero attention is its anti-bacterial and anti-microbial characteristics. This is somewhat ironic, given the current environment and the fact that copper's ability to reduce infections was known as early as 3200 B.C.

Coronavirus Survival on Common Surfaces - Days



Sources: Jefferies Research; Cleveland Clinic, Q2 2020

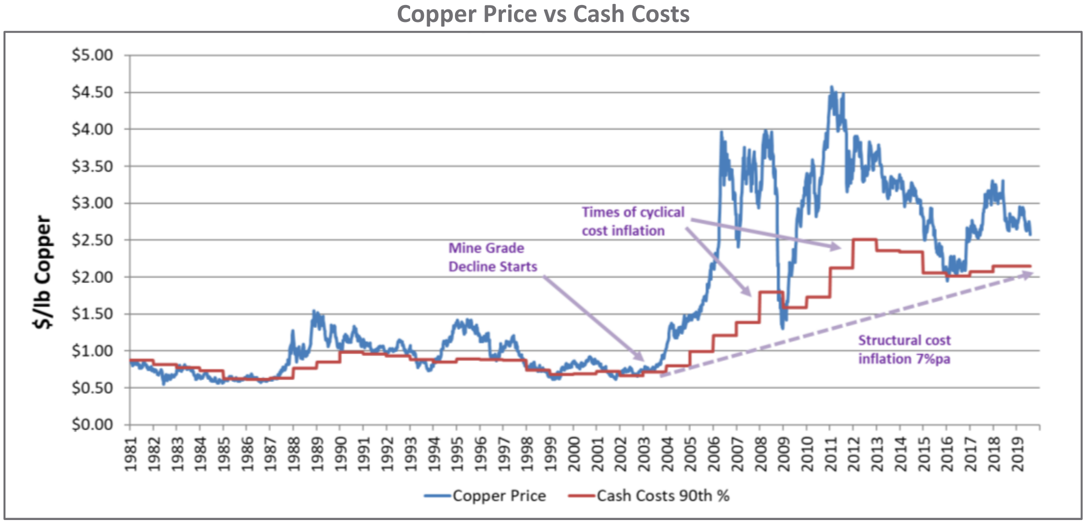
Hospitals have been slow to adopt more copper-intensive interiors, despite the empirical data which show that copper reduces the microbial burden on hospital surfaces by as much as 80% vs the control group[7]. Going forward, it seems more likely than ever that healthcare related demand will increase.

In aggregate, these demand estimates may be too high given the potential for thrifting and new technologies to mitigate the pace of growth. However, they are indicative of the increase in copper production that will be required to facilitate what all observers recognize as central components of the energy transition: increased EV penetration, the rapid conversion of the global power generation stack to renewables combined with the infrastructure development which will be necessary to support these new sources of demand and production.

From this perspective, the concern for copper is not demand, it's supply.

Unlike unconventional oil and gas, copper has not benefited from deflationary technologies. In fact, both capital intensity and operating costs have been rising over the last decade, driven by declining grades, increasing mining depths and the resulting increase in ore hardness – all characteristics of a rapidly maturing production base.

Copper Price vs Cash Costs

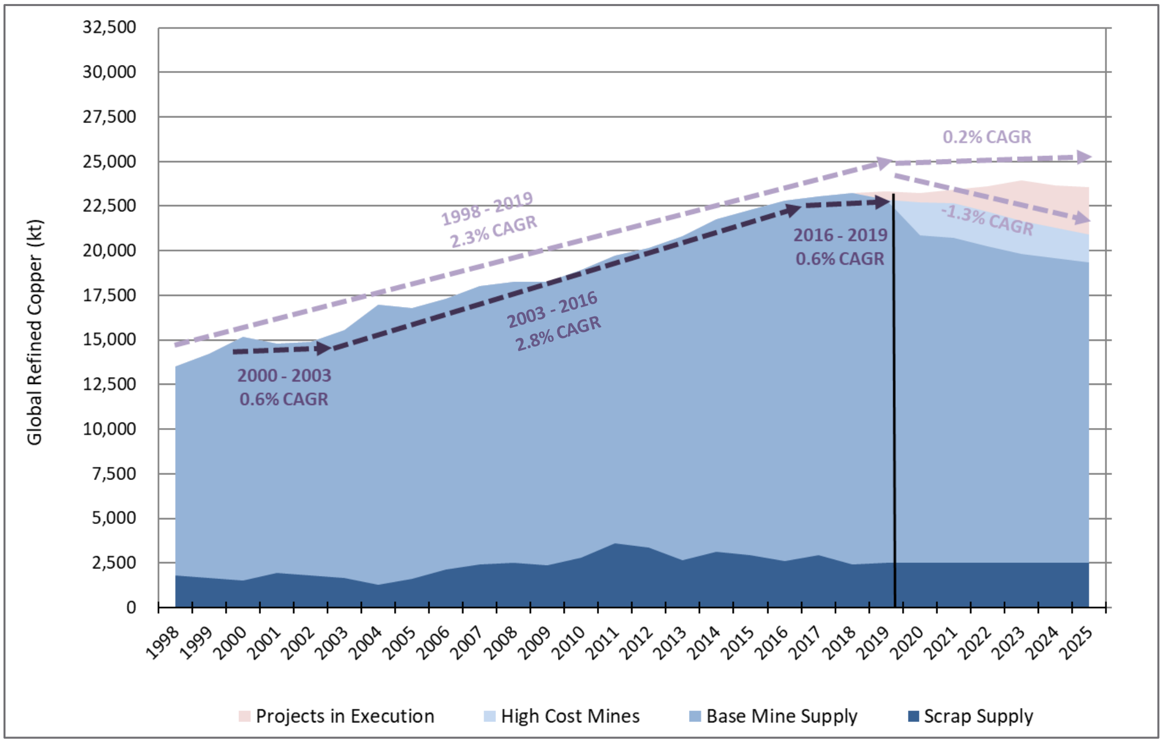


Sources: Wood Mackenzie; SailingStone Capital Partners, Q2 2019

[7] Schmidt MG, Attaway HH, Sharpe PA, et al. Sustained reduction of microbial burden on common hospital surfaces through introduction of copper. *J Clin Microbiol*. 2012;50(7):2217-2223. doi:10.1128/JCM.01032-12

This is in spite of the significant increase in new mine supply in the 2003-2016 timeframe, which was largely driven by the rapid rise in commodity price as seen in the chart above.

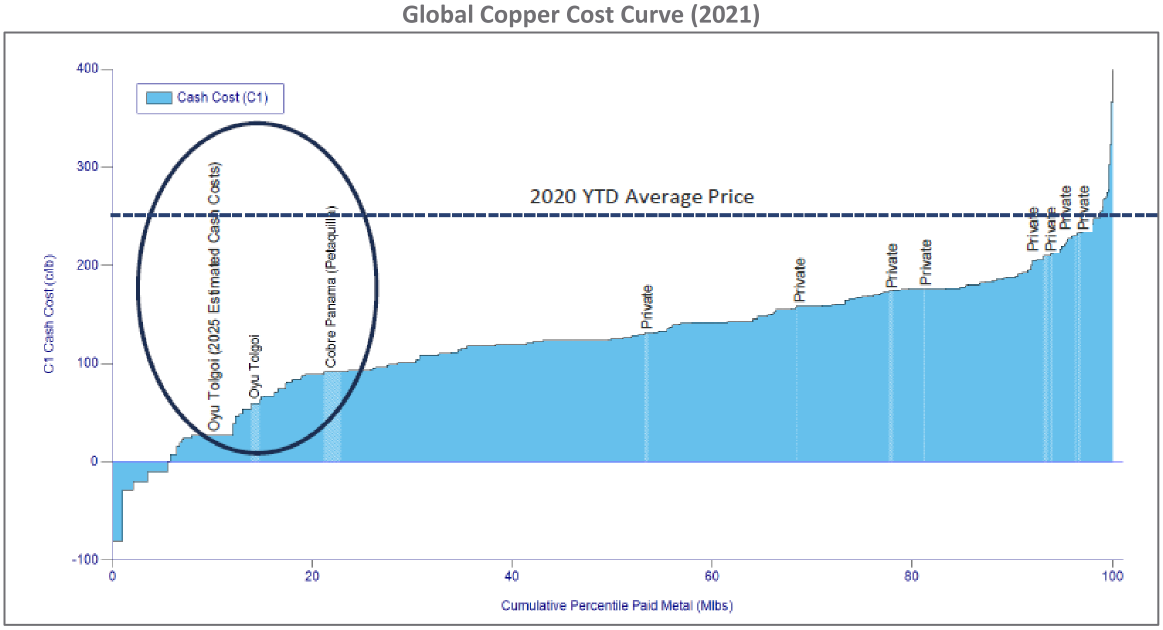
Global Copper Supply



Note: High cost mines defined as having cash and sustaining costs greater than $2.75/lb Cu.
Sources: SailingStone Capital Partners estimates; Wood Mackenzie Q2 2019

After the expansion boom came the inevitable bust, and copper price fell. Supply growth has slowed dramatically as well. This is consistent with the observation that, like natural gas, the global cost curve for copper is quite steep and requires a price signal to expand production.

Global Copper Cost Curve (2021)

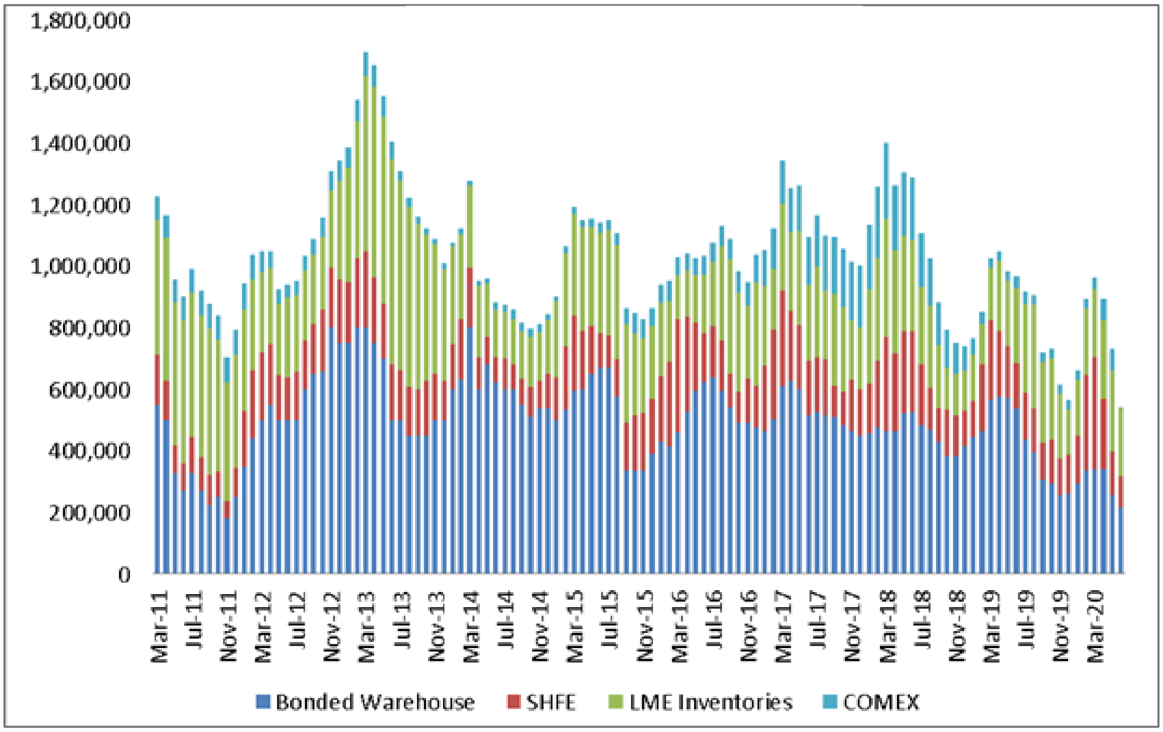


Sources: SailingStone Capital Partners LLC; Wood MacKenzie, Q3 2018
Portfolio holdings are subject to change and should not be considered a recommendation to buy or sell specific securities. The specific securities identified are not representative of all securities, purchased or sold or recommended for advisory clients, and it should not be assumed that investment in the securities identified was or is profitable.

The chart above only shows cash costs, given the much shallower depletion rate of mining assets versus natural gas or oil. However, assuming average capital intensity for a new project of about $22,000/annual ton of production and a 15% required pre-tax cash-on-cash return, incentive prices range from $3.25-$3.50/lb. Not surprisingly, supply growth has largely ground to halt since 2014, as prices have not supported new-build economics.

From a commodity perspective, this presents a most compelling construct. Copper demand has remained robust, despite threats from the US/China trade war, and more recently concerns about the impact of COVID-19. In fact, copper inventories are at decade lows and are down 36% year-over-year despite these headwinds.

Total Copper Inventories

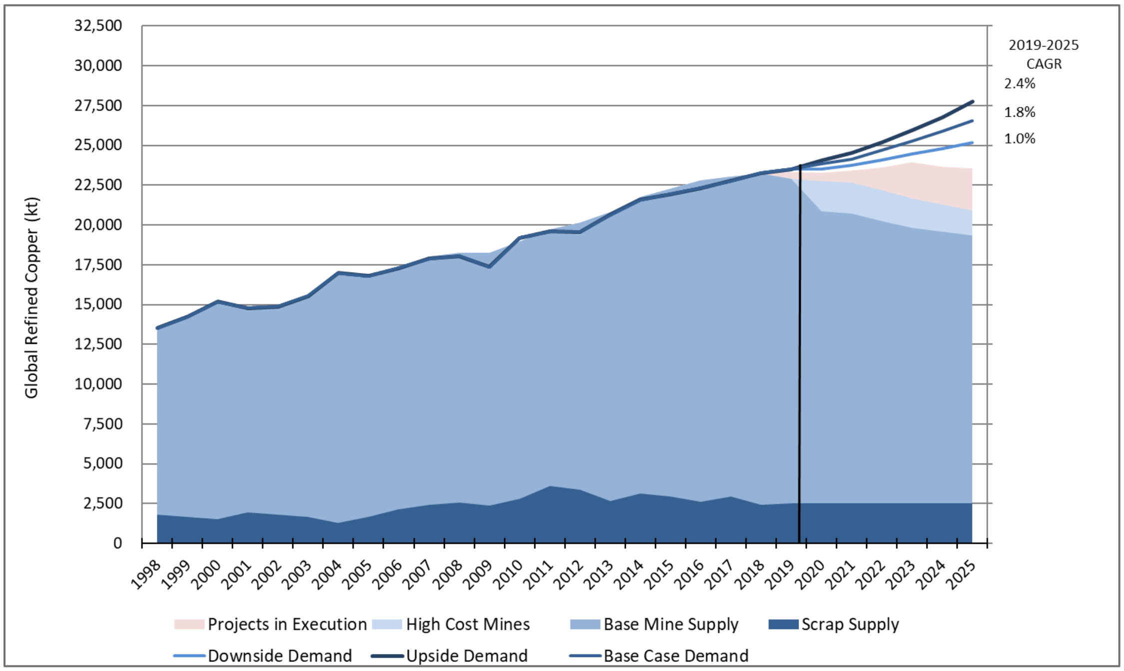


Source: Scotia Bank Research, June 24, 2020

The outlook for future demand looks quite positive as well, given the central role that copper will play in the energy transition.

The supply base, however, is stretched with limited ability to meet even modest demand growth, as evidenced by current inventories and by looking at different demand scenarios relative to future supply.

Global Copper Supply and Demand



Sources: SailingStone Capital Partners estimates; Wood Mackenzie 2Q 2019
Note: High cost mines defined as having cash and sustaining costs greater than $2.75/lb Cu.

Mine development is anything but short cycle – it takes about a decade to permit, construct and commission a new mine, meaning that a sustained increase in demand would result in a rapid and likely sustained increase in commodity prices. And, there have been very few truly Tier I discoveries over the past 30 years, all of which results in a commodity market that is far more likely to be in deficit than surplus over the next several years. Price will have to reflect this reality.

The copper cost curve is steep, supply growth is limited by both geology and the commodity price, and the most attractive assets sit in the hands of public companies

The outlook is even more constructive from an investor's perspective. The copper cost curve is steep, supply growth is limited by both geology and the commodity price, and the most attractive assets sit in the hands of public companies. And, there remains a significant valuation discrepancy between the prices paid for producing assets by strategic, long-term owners and what is discounted in public equity prices today.

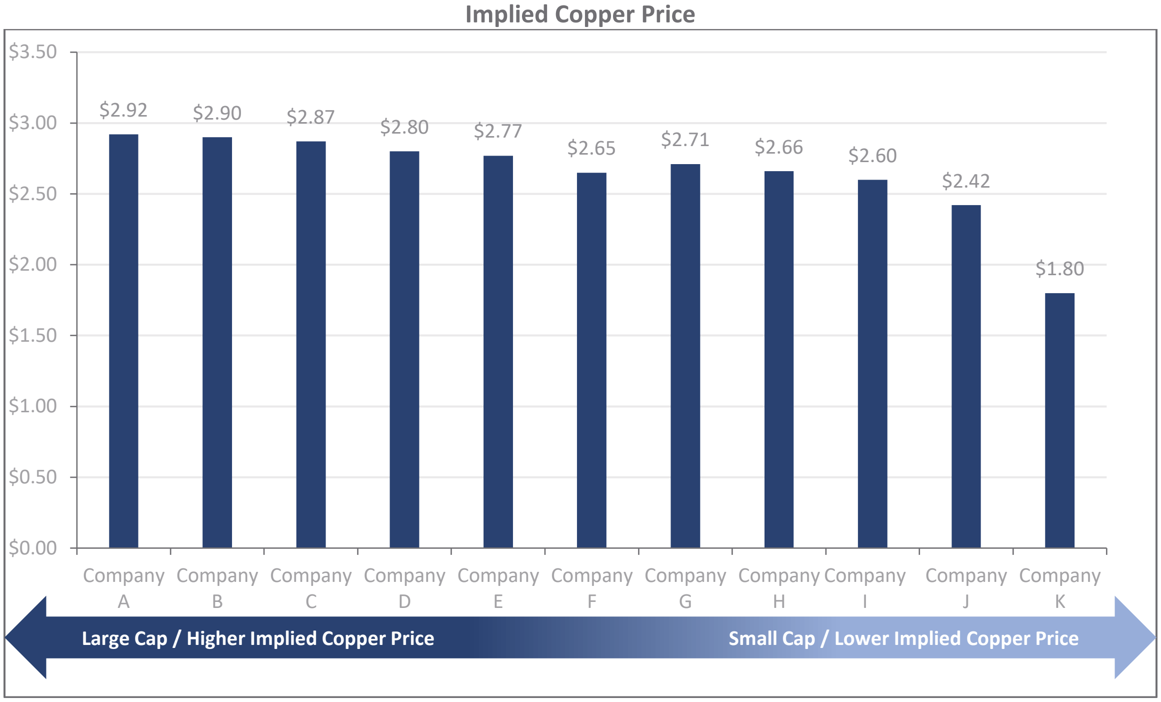
Asset Transactions by Industry Participants

Date	Acquirer	Seller	Asset	Interest	Price	Reserves	Annual Production	Implied Return @ $3/lb Cu	Implied Copper Price @ 10% IRR	Value Per Pound Ore Reserve
					$m	Cu Equiv Kt	Cu Equiv Kt	% IRR	$/lb Cu Equiv	$/lb Cu Equiv
Apr-13	Capstone	BHP	Pinto Valley	100%	650	767	45	10	3.02	0.38
Feb-14	Hudbay	Norsemont	Constancia	100%	366	2,727	0	13	2.90	0.06
Apr-14	MMG	Glencore	Las Bambas	100%	10,000	8,147	400	6	3.72	0.56
Oct-14	Lundin	Freeport	Cadelaria	100%	1,150	2,174	150	7	3.25	0.24
Jul-15	Antofagasta	Barrick	Zaldivar	50%	1,005	2,513	130	6	3.35	0.36
Feb-16	Sumitomo	Freeport	Morenci	13%	1,000	10,888	480	5	3.42	0.32
Mar-16	Boliden	First Quantum	Kevitsa	100%	715	811	65	11	2.95	0.40
Jul-16	China Moly	Freeport	Tenke	56%	2,770	3,205	220	4	3.93	0.70
Oct-16	China Moly	Lundin	Tenke	24%	1,187	3,205	220	4	3.93	0.70
Jul-17	First Quantum	LS Nikko	Cobre Panama	10%	635	11,113	0	17	2.45	0.26
Sep-18	Zijin	Nevsun	Timok	100%	1,410	984	0	6	3.49	0.65
Dec-18	PT Inalum	Rio Tinto	Grasberg	40%	3,500	37,050	514	9	3.15	0.11
Dec-18	Sumitomo	Teck	QB2	30%	1,200	7,325	0	6	3.50	0.25
Mar-19	Newcrest	Imperial	Red Chris	70%	806	9,597	49	8	3.25	0.05
Apr-19	Lundin	Yamana	Chapada	100%	800	2,192	73	9	3.18	0.17
Apr-19	Zijin Mining Group	Ivanhoe Mines	Kamoa-kakula	39%	1,530	4,770	0	6	3.60	0.37
								Weighted Average	3.25	0.25

Sources: SailingStone Capital Partners estimates; Wood Mackenzie 2Q 2019

Producing assets have traded hands at prices which discount $3.25/lb copper based on reserves, while state-backed buyers have paid closer to $3.50/lb, not coincidentally in-line with our estimates of current incentive pricing.

Public equity valuations are well below these levels, particularly for some of the smaller cap companies that own the few development projects that are expected to come online in the next couple of years.



Source: ScotiaBank, May 2020

Energy transition-driven demand for copper will create similar dynamics to those we are witnessing in natural gas

In our opinion, the opportunity in copper looks very similar to the one in natural gas. Investors can acquire stakes in low-cost, long-lived reserves at a steep discount to intrinsic or replacement value just as we move into an environment where energy transition-driven demand and a fully utilized supply base is far more likely to result in commodity beta acting as a tailwind to returns than a headwind. Furthermore, copper largely is technology agnostic in the context of the energy transition and is unlikely to be substituted away even over the long-term given its unique physical and technical characteristics. As these dynamics unfold in the coming years, we believe that what is viewed today as a liquid call on short-term global economic activity will increasingly be regarded as a scarce, integral component of the energy transition. Counter-cyclical investors would be wise to take notice.

FLIES IN THE OINTMENT?

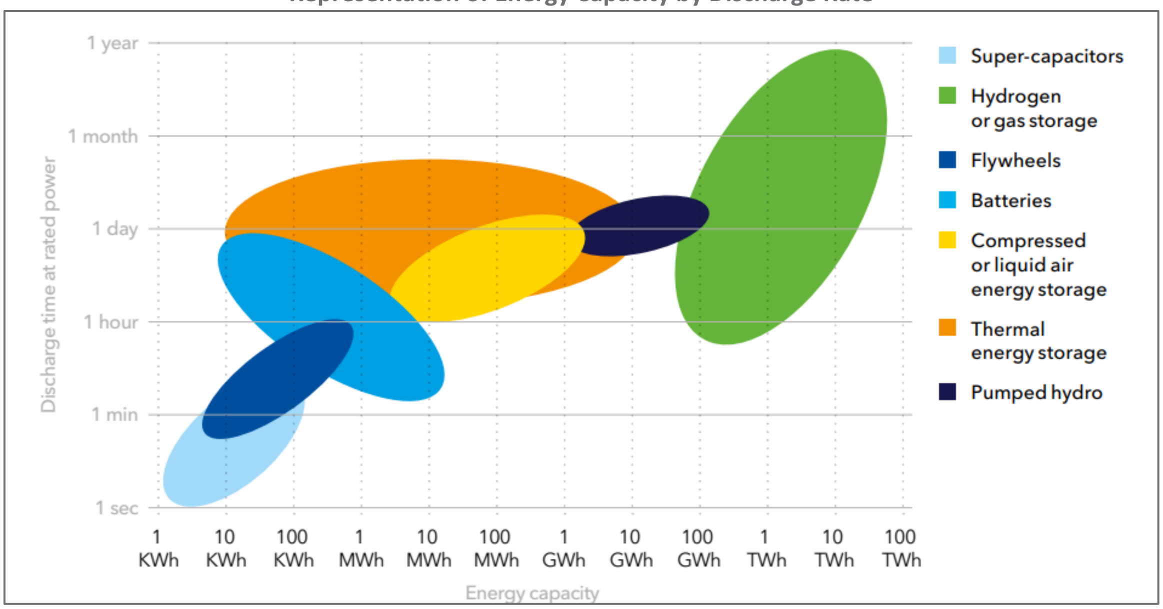
Obviously, there are an enormous number of variables and assumptions embedded in these scenarios and we know that technology and innovation will impact whatever end state is attained. Therefore, it is important to identify and monitor any developments or alternatives whose widescale implementation would obviate a conclusion. Two areas which could influence the outlook for natural gas, and to a much lesser extent copper, are grid-level storage and hydrogen.

Storage

Theoretically, utility-scale storage accelerates the progress to net zero emissions by allowing electricity from intermittent renewables like solar and wind to be utilized based on demand versus resource availability. However, there are two fundamental challenges with storage. First, at the highest level, solar and wind have capacity factors of 25-35%, meaning that installed capacity must be 3-4x greater than demand assuming 100% renewable generation. Relying on renewables to fill storage as a way to manage through periods of negligible resource availability would require even more capacity additions than are already being planned, plus significant incremental investments in the grid. Given the massive amount of capital that will be required to meet current renewable forecasts, this may be an impediment to universal storage rollouts.

Furthermore, virtually all utility-scale storage projects today are based on short-duration lithium-ion batteries, with a discharge/recharge time of approximately four hours. Lithium-ion batteries have high power and energy density and fast response times, characteristics which are suitable for small consumer devices and light vehicles but are not ideal for a grid, which requires a longer duration, higher capacity storage system.

Representation of Energy Capacity by Discharge Rate



Source: DNV-GL Energy Transition and Outlook 2019

A proven long-duration battery storage technology currently does not exist, although there are some encouraging signs of progress. One of the most advanced from a commercial perspective is from Form Energy, which recently announced a pilot project with Great River Energy in Minnesota to replace a coal plant which is approaching decommissioning with wind plus a 150mWh storage solution using their aqueous air battery system. The project is expected to come on-line in 2023, and interestingly will be combined with the reconfiguration of a small power station and biorefinery to be fueled with natural gas.

We expect that utility-scale storage technologies will continue to advance and over time will displace some portion of the existing hydrocarbon-based generation capacity. The pace of development as well as the scale of renewable penetration will dictate both the magnitude and the timing of that dislocation. It is a trend worth watching, but the quantum of required investment and the associated lead times suggest that storage does not present a material threat to natural gas demand in the investable future.

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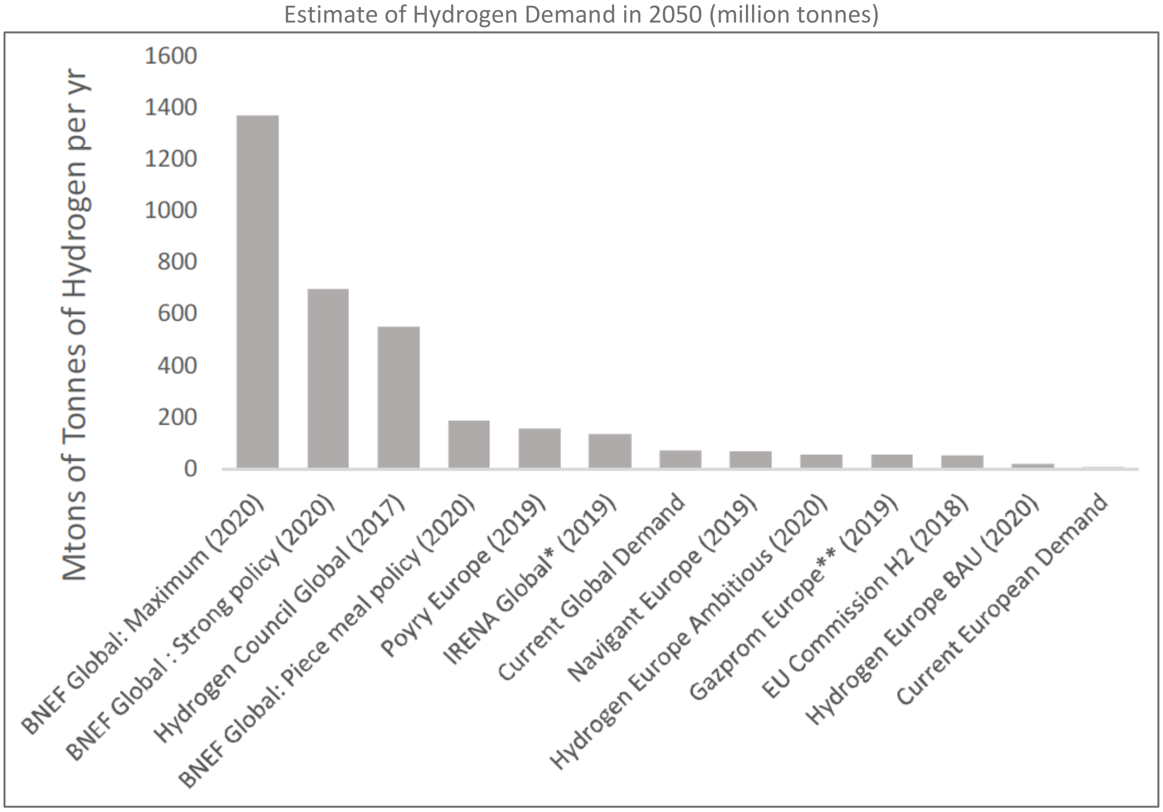
Hydrogen

While individual companies are working to progress storage technologies, entire countries are throwing their support behind hydrogen as a key enabler of a zero-carbon future. Japan has announced that it intends to become the first major hydrogen economy between 2030 and 2050, and the EU is expected to publish its Strategy on Hydrogen in early July.

What is the appeal of hydrogen? First, it is widely available and has a high energy intensity, storing almost 2.5x as much energy/kg as natural gas and more than 3x gasoline. Second, it is highly flexible as it can burn in a turbine or be consumed in a fuel cell with zero $C0_2$ emissions. Lastly, “green” hydrogen can be produced carbon free via the electrolysis of fresh water powered with renewables.

As a result, some forecasters are calling for up to 700 million tonnes per annum of global hydrogen production by 2050, a 10x increase in supply which would meet ~20% of global energy demand on the back of $10-20 trillion in total investment. However, there remains a wide range of opinions regarding 2050 hydrogen demand.

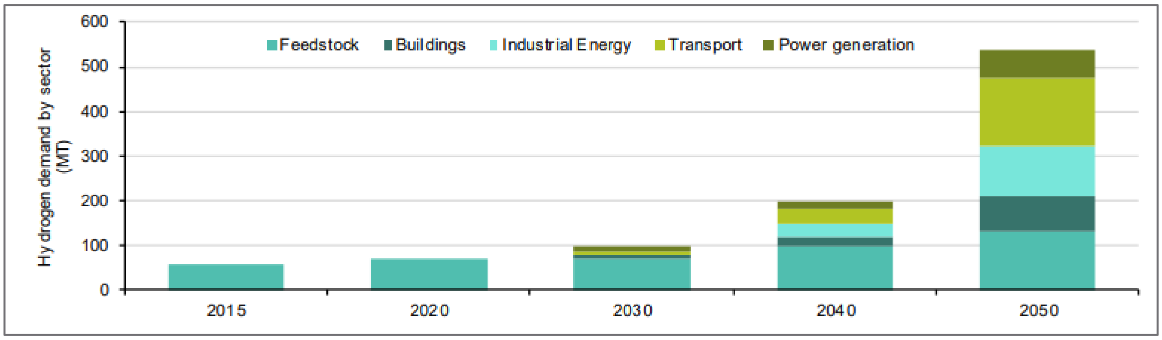
Estimate of Hydrogen Demand in 2050 (million tonnes)



Note: * from renewables only ** from natural gas only.
Source: JP Morgan Cazenove, June 4, 2020

In the context of the energy transition and hydrogen’s impact on natural gas and copper, two aspects are worth considering. First, from a demand perspective, hydrogen’s physical characteristics make it most suitable for use in the transportation sector, largely in heavy duty terrestrial and maritime applications, as well as a fuel to power industrial processes and to heat buildings.

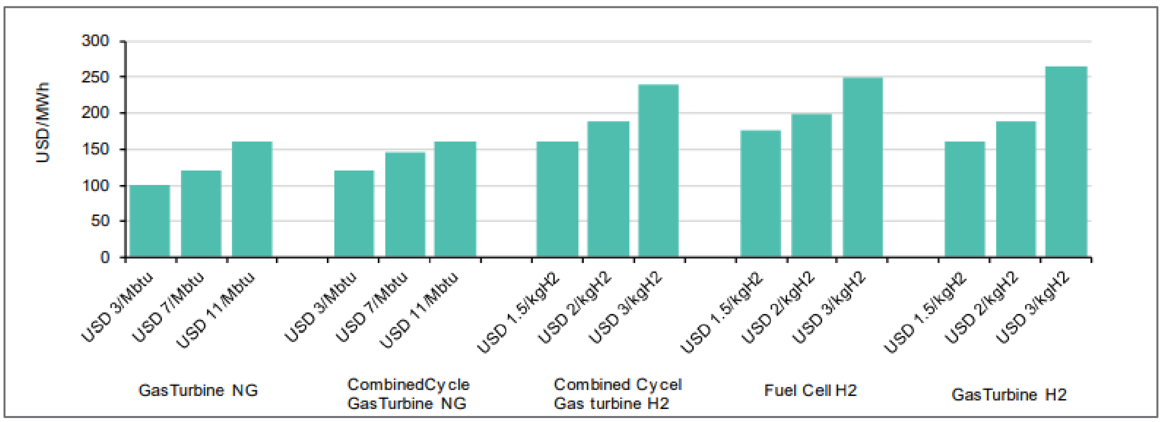
Hydrogen Demand by Sector



Source: Bernstein Research, *Climate Change and Decarbonisation: The hydrogen highway – a primer*, September 10, 2019

While this outcome could curtail a portion of future natural gas-fired electricity demand, it seems far more likely to impact oil, the primary transportation fuel today. Of note, the substitution of green hydrogen for natural gas in the power stack is not economic, even assuming significant reductions in hydrogen production costs, much higher natural gas prices, a \$50 per ton CO_2 emission tax and 100% localized green hydrogen production.

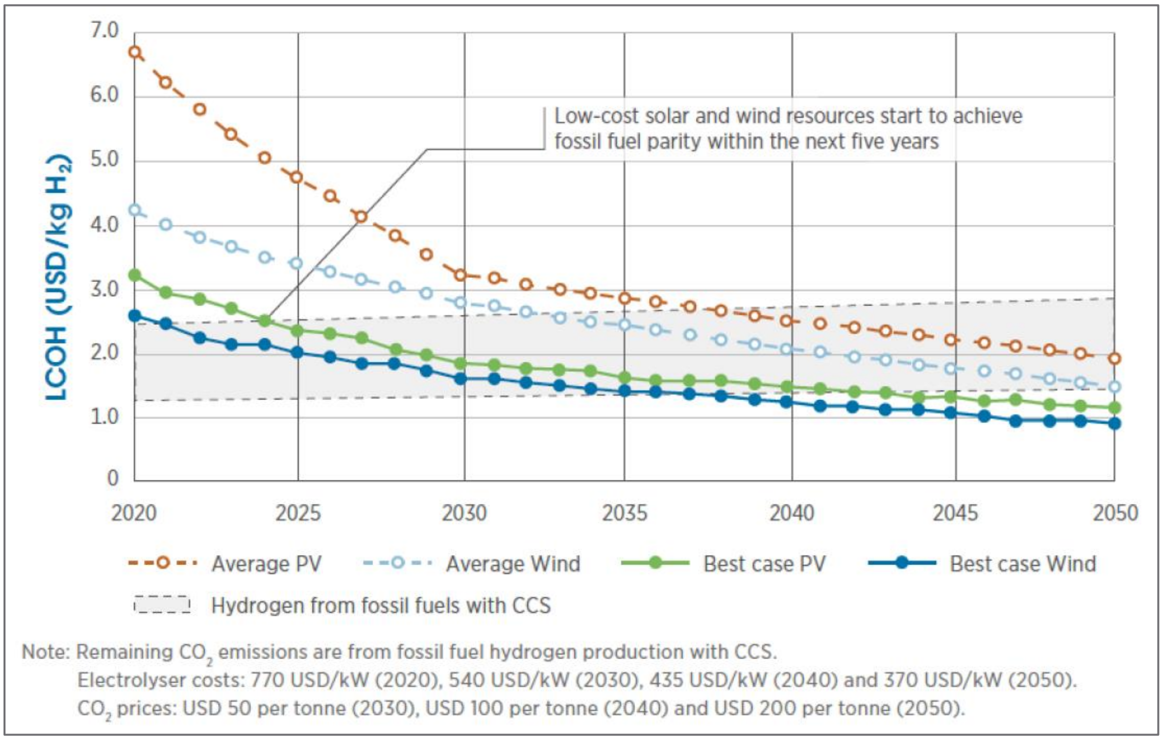
Cost of Substitutes for Natural Gas in the Power Stack



Source: Bernstein Research, *Climate Change and Decarbonisation: The hydrogen highway – a primer*, September 10, 2019

For context, hydrogen prices aren't forecast to approach cost-equivalence with \$3 natural gas-fired combined cycle turbines until 2035-2040 under the most optimistic "best case" scenario which includes significant improvements in electrolyser efficiencies and much higher carbon taxes.

Hydrogen Cost Projections



Source: JP Morgan Cazenove, June 4, 2020

Even in the most bullish forecast for hydrogen production, the impact on natural gas appears limited until 2040 or later.

Second, there are serious constraints to supplying enough green hydrogen to meet the more aggressive projections. Current electrolysis technologies require fresh water, and while the byproducts of hydrogen combustion are energy and (acidic) water, little of the wastewater is recycled. In addition, electrolysis is incredibly power intensive. 1 kg H_2 requires 9 kg H_20 and consumes 50 kWh of electricity using current electrolysis technology running at 80% efficiency.

Assuming that all green hydrogen is produced and consumed locally (i.e. ignoring the ~30% losses that occur when converting hydrogen gas to liquid as well as the incremental energy consumption), 700 million tonnes of hydrogen would require 6.3 trillion m^3 of fresh water and 35,000 tWh of electricity per annum. This is about 16x the amount of fresh water consumed in the US each year, and more than 50x the amount of fresh water used for thermoelectric processes in 2015, the last year that specific data were available from the USGS[8]. Furthermore, 35,000 tWh of electricity consumption is about 1.6x total global electricity consumption in 2019. With relatively low capacity factors, this would require an incremental 60,000 tWh of renewables to be installed by 2050 as a way to power the zero emission conversion of a finite, precious resource into enough hydrogen to meet 20% of 2050 energy demand.

Based in large part on these constraints, the more likely path is that "blue" hydrogen, sourced from natural gas, is the bridge to a "green" hydrogen future. This sequencing would allow renewables to be prioritized to displace carbon-intensive power such as coal while technological advancements in electrolysis reduce resource consumption and unit costs and hydrogen-related infrastructure is built out. No one questions the political and

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[8] Water consumed in thermoelectric processes is the most often referenced source of fresh water that would become available if hydrogen replaced all hydrocarbons in the power stack. The most recently available data was 2015, which saw an 18% reduction in water consumption per kWh versus 2010, due in large part to more efficient cooling technologies and the fact that natural gas continues to take share from coal. Presumably, 2020 data will show similar improvements.

industrial momentum around hydrogen as an increasingly important component of the energy transition. However, the probability that it displaces significant amounts of natural gas in the foreseeable future is quite limited, in our opinion.

CONCLUSION

Mercifully, this report is not intended to be an exhaustive review of all aspects of the energy transition, nor have we attempted to investigate how it impacts every commodity. Undoubtedly, we are wrong about many of the specifics in our forecasts, estimates and extrapolations. Such is the nature of these exercises.

However, we have observed that many institutional investors have overlooked critical aspects of the energy transition and the enabling role that specific commodities will play in its ultimate success. In addition, recent investment returns and the actions of some industry participants have made it easy to relegate an entire sector to the investment "sin bin."

We believe that the reality is more nuanced and is much more prospective than most investors appreciate today

We believe that the reality is more nuanced and is much more prospective than most investors appreciate today. While thermal coal is a dying commodity, and oil demand will ultimately be impacted by EVs, it is impossible to imagine how the path to a zero-emission future does not require more natural gas and copper. Critically, investors can access the most attractive projects in each commodity via companies with strong ESG track records at a point in the cycle when mission-critical inventory is being given away essentially for free.

Today, long-term, counter-cyclical investors can both participate in and accelerate the energy transition while generating abnormally attractive returns for their constituents. What can be more responsible than that?

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